PREPARED BY Hairspring VIBRATING CO. Div of TORQUE CONTROLS, INC.
ELECTRONIC MECHANICAL CHEMICAL

BOX 330 UNION CITY • NEW JERSEY
CABLE VIBRA • TEL UNION 5 1982

FOR PICATINNY ARSENAL, DOVER, N.J

SUMMARY REPORT

ENGINEERING AND PRODUCTION OF MOVEMENT ASSEMBLY MT, 90 SECOND, T5E1

CONTRACT NO. DA-28-017-501-ORD-4029

FOR
UNITED STATES ARMY MATERIEL COMMAND
DEPARTMENT OF THE ARMY
PICATINNY ARSENAL
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Prepared by Charles Verde

Charles Verde, Proj. Dir.

AUGUST 1959
THROUGH TO
OCTOBER 15, 1963

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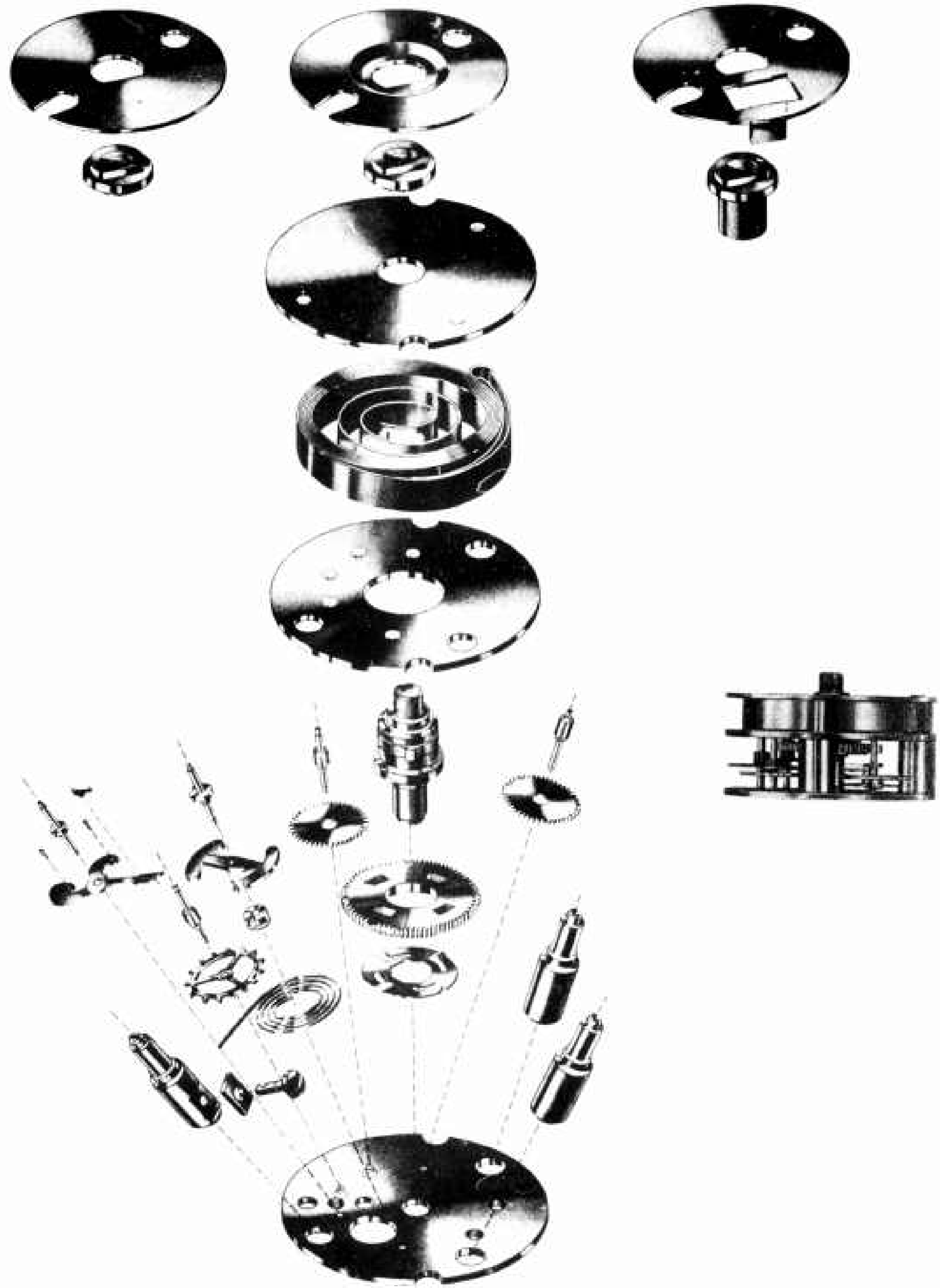
T4E1 T5E1 T3E2



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ELECTRONIC Hairspring VIBRATING CO.
MECHANICAL CHEMICAL
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SECTION I

FOREWORD

This Summary Report describes the Engineering and Production of Movement Assembly, MT, 90 Second, T3E2, T4E1 and T5E1 for Mechanical Time Bomb Fuzes. The work performed by the contractor, Hairspring Vibrating Co., covered the engineering of the movement assembly to effect a self-starting unit, minimize costs, reduce lead time, assure the production rate of 100,000 units per month and a sufficient quantity of test samples were fabricated to prove out the engineering performed.

Our approach was to strengthen the weak areas of both the R&D and partially production engineered version and to eliminate the extreme manufacturing difficulties encountered by producers of the R&D models. Sketches and models were made. Frequent engineering conferences were held with the arsenal representatives to evaluate contractor sketches, models, test results and recommendations. Drawings were revised to reflect the conclusions arrived at.

Bodies of both the R&D T3 and the partially production engineered T5E1 were modified to accept the new components proving the respective re-design. Following the test and prototype phases, Government owned tooling was modified and complimented with the manufacture of auxiliary jigs and fixtures.

Since the "Scope" did not include hard tooling, only soft tooling was used to make the test samples proving out drawing changes. No hard tooling was made for the subsequent fabrication of the 25 Pilot Lot and 250 Production Quantity.

Difficulties were resolved in the areas of gearing, mainspring specification and testing, measurement of surface roughness and waviness, escapewheel manufacture and lubrication. Closing documents consisted of Final Drawings, Specification Draft, Notes on Development Type Materiel, Inspection Equipment Concept Sketches, Sequence of Operations, Final Summary Report and a Lubrication Study.

SECTION II

SUMMARY OF SPECIFIC ENGINEERING MODIFICATIONS BY AREA

I ESCAPEMENT

A. A detached pin and lever escapement was used to replace the R&D Yunghans type escapement virtually eliminating torque and position sensitivity, and greatly increasing cycle completion reliability.

B. Torque sensitivity was eliminated by the inherent insensitivity of the pin and lever design.

C. Position sensitivity was eliminated by dimensioning the pallet and components of the balance assembly to locate the center of gravity on their respective axis, by maintaining minimum pivot/bearing looseness of the balance assembly and by designing minimum mass with a maximum balance inertia.

D. Various escape wheel teeth profiles, tolerances and impulse face surface finishes were tested to effect good performance with minimum cost yet maintaining isochronism.

E. Attachment of the hairspring was simplified providing a secure lock yet permitting beat rate adjustment when needed in the final assembly.

F. All parts and assemblies of the escapement were ruggedized to withstand the higher than normal torque transmission and rough handling tests.

II TORQUE TRANSMISSION

A. Torque delivery was increased through a redesigned winding mechanism and center arbor, thus providing additional space for a larger mainspring. Torque delivery was held at a more constant delivery by a symmetrical distribution of the pillar posts.

B. Difficulty in obtaining correlation of mainspring torque measured by various testing apparatus resulted in the design of a simple test fixture for use in acceptance of mainsprings from subcontractors.

III GEARING

Both cycloidal and involute tooth form gearing were tested. Cycloidal was chosen for the final design.

IV MOUNTING ERRORS

To assure proper alignment and ease of final assembly, the ideal or basic relationship was established for each mating component and held to tolerances consistent with method of manufacture.

V MOUNTING PLATES

A. Minimum thickness of the plates consistent with securely containing gearing and escapement sub-assemblies during extremes of shock and vibration was accomplished by proper positioning of supporting pillar posts.

B. Tests were conducted to determine the effect of pivot bearing surface micro-finish and countersinking of the pivot holes on the beat rate.

VI STAKING OF SUB-ASSEMBLIES

Staking operations were given careful study with regard to withstanding torque, loads and rough handling.

VII LUBRICATION

The original intention to design an unlubricated movement assembly was abandoned when a loss of beat rate at -65°F occurred. An intensive study of available lubricants resulted in the use of a dry lubricant in the final design.

SECTION III

NARRATIVE OF SPECIFIC ENGINEERING PERFORMED BY AREA

I ESCAPEMENT

A. General Discussion

The main change which was proposed to increase functioning reliability and reduce manufacturing difficulties of the R&D designed movement assembly was to replace the Yunghans type escapement with a detached pin and lever escapement. The advantages over the R&D designed escapement are as follows:

R&D Design	P.E. Design
Torque sensitive	Relatively torque insensitive
Position sensitive	Relatively position insensitive
Requires impulse starter	Self-starting with high starting reliability
Poor timing accuracy	High timing accuracy
Poor cycle completion reliability	High cycle completion reliability
Requires selective assembly of pallet and escape wheel	No selective assembly required

In order to determine the general design of the escapement, a Meylan 1/10 second fast beat stop watch was used, the following parts of which were modified to fit the R&D and partially production engineered movement assemblies:

a. The escape wheel was fitted to the R&D pinion.

b. The pallet lever was bent to fit the curvature of the R&D plates and a new pallet/balance center distance was located.

c. A new balance shaft with rugged .016 inch diameter straight shank pivots was made and fitted to the Meylan balance.

d. The Meylan safety roller was modified to fit the new balance shaft.

e. The Meylan roller jewel was replaced with a .012 inch diameter rugged, steel, straight shank impulse pin.

f. A series of graduating strength hairsprings were experimentally selected from our large range of stock sizes.

The hairspring strength was gradually increased until its restoring torque was equal to the force exerted by the draw angle of the escape wheel. At this point, oscillation of the balance was maintained at a high amplitude. The beat rate of the balance was then steadily increased through the use of stronger hairsprings and lighter balances. Various beat rate testing apparatus and a means of directly reading the rps of the output shaft were used to determine the beat rate as well as its consistency. The final configuration of the balance was a spoke having a small mass at each end.

Having ascertained that inertial restraints would pose no serious obstacles to proving our "approach", theoretical studies were conducted to determine the geometry needed to ensure a balanced pallet lever to fit the T5E1 movement bodies.

A range of beat rates were experimentally determined which, when used with the available gearing from the previously partially production engineered T5E1 movement assembly, would perform satisfactorily under extremes of temperature and vibration. A beat rate of 25 beats per second was chosen as the best to use as relating to the reduction gearing ratio and the required output shaft rps. Report No. 6 shows the test results obtained from these modified movement assemblies. The balance amplitude ranged from 180° to 530° for input torques ranging from 4 to 40 ounce inches.

As finally designed, the average torque-amplitude test results at various input torque levels using the final designed 23 oz. in. mainspring were:

Rev. from full wound	Output Shaft Torque (oz.in.)	Balance Amplitude (deg)	% change
0	23 3/4	370	-0-
1/2	23	360	-0-
1	22	360	-0-
1 1/2	21 1/2	360	-0-
2	20 1/2	350	-0-
2 1/2	19 1/2	350	+.005
3	18 1/4	340	+.01
3 1/2	17 1/2	340	+.03
4	16 1/4	320	+.05
4 1/2	15 1/2	290	+.10
5	12 3/4	270	+.19
5 1/2	12	220	+.27

B. Torque sensitivity

Torque sensitivity was at no time a problem due to the detached nature of this pin lever escapement. In this design the escape wheel pulses the pallet lever which in turn pulses the balance and spring as the balance mass is passing through its neutral position. In this position of greatest balance velocity, frequency of oscillation is independent of the driving force. The balance then is in a free swing and coils the hairspring to which it is attached. The recoil action of the hairspring returns the balance unlocking the pallet from the escape wheel. The pallet lever then receives a pulse from the escape wheel and in turn pulses the balance and the cycle is repeated. The actual timing control (the balance) is in contact with the pallet lever less than 5% of the time and therefore friction is minimized. Thus, the main reason for torque insensitivity is that the pulse is applied over the neutral portion of the arc of the oscillating balance, with maximum force and maximum velocity.

Torque sensitivity in the R&D designed escapement is attributable to the fact that impulses do not average about the neutral position of the pallet lever. Locking impact occurs when the pallet lever is farthest from its neutral position adding friction to the pallet pivots. Slight friction added to a deep escape-pallet lock will stop the lever motion. With essentially no free swing and a great deal of friction, the timing accuracy is much more dependent upon the pulse force than is the detached pin lever escapement. Because of the gearing up of timing mechanisms, the actual power transmitted to the escapement is only a fraction of that which the mainspring delivers. Any friction in the bearings, gearing and escapement detracts from torque available from the power source. As the mainspring unwinds the available power decreases, the rate of the applied pulse force decreases due to the opposing sliding frictional force between the pallet and escape wheel. The sliding frictional force increases as the pulse rate decreases, thereby an increasing opposing force is applied and the timing inaccuracy multiplies. Only if the available power remains constant at the escapement can the Yunghans escapement be torque insensitive and have good accuracy.

With the P.E. hairspring fastened to the post, the balance pivot, when not more than .050" from its bearing hole, will be isochronous i.e., the balance will perform each oscillation in near equal time throughout the run of the mainspring. The worst possible condition, which could escape visual detection after assembly, has no significant effect upon the critical first 1 1/2 revolutions from full wound. Contributing to this isochronal effect are the properties of the mainspring, gearing, concentricity of mounting, balanced pallet and balance and Ni Span "C" hairspring material. Most important, however, is the design relationship of the outer hairspring end (fastened at the post) to the inner end (fastened to and generating from the hairspring hub). This accomplishes an equalization of the hairspring "recoil force", symmetrically unlocking the escapewheel on either side. The escapewheel reciprocates with a symmetrical pulse through the pallet pins to the balance. Thus the periodic times of each swing are symmetrical notwithstanding loss in both mainspring torque and related balance amplitude.

C. Position Sensitivity

The P.E. balance and hairspring assembly is inherently torque insensitive due to the fact that its center of gravity is essentially concentric with its axis of oscillation. The high balance inertia also contributes to its cyclic regularity. The pallet lever when assembled with its various components, is essentially a balanced assembly. Its center of gravity was both theoretically computed and experimentally adjusted thereby avoiding possible position sensitivity.

In the R&D designed escapement the pallet is not balanced and its low inertia is easily influenced by changing pivot stresses in various positions.

D. Escape Wheel

An escape wheel tooth profile designed to impart a constant rate of acceleration to the balance showed no improvement over the standard constant velocity profile. Various draw and impulse angles and surface finishes of the standard constant velocity design were tested to obtain the optimum performance. During the testing, it was found that the small area presented by the escapewheel lift angle resulted in difficulty in measuring its surface finish. Local Testing Laboratories had no means for a direct microfinish measurement of such small areas. As it was necessary to support experimental results with objective data, as opposed to questionable psychophysical visual inspection, a search for adequate instrumentation resulted in the selection of a Micrometrical Manufacturing Company Proficorder, the only standard instrument available.

As a result of this testing, it was concluded that none of the tested conditions significantly improved or detracted from the results obtained using escapewheels to the original specified dimensions. A considerable lessening of tolerances and surface roughness and waviness resulted. These wider tolerances opened the way for the manufacture of a die stamped part, thus reducing costs. Such a die was fabricated, stamped escapewheels were incorporated into test movements, and the performance was most satisfactory.

E. Attachment of Hairspring

A means of attaching the outer end of the hairspring required careful study since we intended to design a "free sprung" spring-mass assembly. "Free-sprung" simply means that the spring-mass breaks away clean, free from error introducing encumbrances e.g., a conventional type regulator.

The final design is simple, inexpensive, allows for final adjustment when necessary and provides a rigid secure fastening which is not affected by vibration or rough handling. This was accomplished through the use of a slot across one pillar post to receive the hairspring, and a milled flat surface with a tapped hole to hold a die stamped hairspring lock.

F. Ruggedizing

It was first thought that conical or cylindrical pivots supported by olived jewels and supporting end stones, as are found in all known accurate timers, would have to be used to obtain the required accuracy. This approach, however, was abandoned early in the project after tests proved their inability to withstand shock. Tests on straight shank pinion and Balance Shaft pivots established that the added friction had no adverse affect upon performance at the planned high beat rate, yet provided a considerable margin of safety in shock and pivot/bearing load carrying ability. Pinion and Balance Shaft pivots were designed to have adequate load carrying and shock resistant capabilities and yet have their shoulders present a minimum rubbing surface area on the supporting plates to minimize friction. Torque transmitting pins were designed with a large rigid base thus providing ample shock and load carrying capabilities.

The Balance Shaft was redesigned to eliminate the separate part "Safety Roller". These two parts are now one component resulting in economies of manufacture and assembly as well as providing an improved quality. This new Balance Shaft was further improved by providing a shoulder or seat for the Balance. This not only provided a greater support for the Balance, but also eliminated the need for special "controlled depth assembly fixtures".

The Hairspring Hub was then designed with an extension on one side to seat directly against the balance thus also being supported by the Balance Shaft shoulder.

The coiled hairspring is secured to the Hairspring Hub by a 90° circular crimp which provides adequate resistance to rough handling. When assembled to the balance and securely fastened to the hairspring pillar post, the balance mass is sufficiently supported and pivot friction is minimized.

II TORQUE TRANSMISSION

A. The torque delivery was increased and held at a more constant output by enlarging the mainspring and by a symmetrical distribution of the pillar posts.

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The symmetrical positioning of pillar posts effects a more concentric unwinding of the mainspring. Frictional losses due to mainspring inter-coil friction and arbor pivot side thrust were considerably reduced.

B. In order to assure that the performance of the movement assemblies fabricated during the contract will be duplicated, it was necessary to include a mainspring test in the specification draft.

Mainsprings procured from different subcontractors with the same stated torque requirement did not reproduce the "under load" beat rates when assembled and tested in movement assemblies. It was found that when the same spring was tested in different torque testing machines, different results were obtained. Therefore, a torque testing fixture was designed, built and satisfactorily proven to be reproducible and capable of assuring mainspring conformance to the torque requirements specified on the drawing. The mainspring drawing was also revised to reflect required material mechanical properties after heat treatment.

III GEARING

Both cycloidal and involute gearing were tested and found satisfactory. The cycloidal was the British Standard 978 Part 2, the involute a 20° pressure angle long and short addendum.

Since the government furnished tooling from the previously partially production engineered movement assembly included dies for stamping the cycloidal tooth form gears, theoretical studies were conducted and compared with measurements of samples made with these dies. The measurements met the calculated results.

Conforming cycloidal pinions were fabricated from drawn pinion stock, the teeth of which were found to be too soft and deformed under the high input torque of the mainspring. Additional pinions were fabricated from a heat treatable drawn pinion stock, but these were found to lack sufficient beam strength. The pinion teeth were then modified by increasing the tooth width and utilizing a 1/2 ogive to relieve tip interference.

The center arbor was also redesigned to accommodate a center gear with a .050 inch face width in lieu of the government furnished .025 inch face width center gear in order to distribute the input torque over a greater pinion tooth area. No wear or failures occurred after these changes.

Involute tooth form gears were also considered for use, as involute profile cutting tools are standard "off-the-shelf" items whereas cycloidal cutting tools are always a special order. Therefore if a manufacturer chose to cut the gears rather than stamp them, the tooling lead time would be less for the involute tooth form.

After careful study of the maze of confusion which shrouds gearing for small mechanisms, theoretical involute data was calculated, gears were cut and pinion stock was drawn. Tests of these manufactured parts, however, showed that drawn pinion stock could not be held to the tolerances required by the action of involute teeth. Acceptable gear trains using drawn pinion stock could only be obtained by selective assembly.

Large scale drawings were made of the involute form to determine the limits of lock-up at one extreme and insufficient engagement at the other. Pinion center distances were adjusted accordingly. Pinion blanks were then manufactured and a standard involute cutter used for cutting the pinion teeth to the required close tolerances. Movement assemblies fabricated utilizing the cut pinions performed satisfactorily. The conclusion arrived at is that closer radial tolerances are required for involute action than for cycloidal action. Due to the "bulby" nature of a drawn pinion, true involute action is not possible and the cost saving feature of drawn pinion stock cannot be realized.

Cycloidal gearing was chosen as the final design because of the following:

a. The involute tooth form must be fabricated to tighter tolerances.

b. Satisfactory involute tooth form pinions cannot be fabricated from drawn pinion stock.

c. Although the initial lead time of obtaining involute tooth cutters is less than that to obtain either cycloidal tooth drawing tooling, the actual production time to produce the involute pinions is greater than that required to produce the same quantity of cycloidal pinions. The cycloidal pinions can be fabricated from drawn pinion rod, but the involute pinions must be fabricated by the slower, more costly, individual tooth milling (hobbing) method. The only advantage of the involute tooth is if the gears were cut instead of being stamped, as there is no standard stamping tooling available for the precision required. Further, the lead time involved is for the gear and pinion tooling only and would not affect the overall lead time for the movement assembly.

d. Involute gearing is more susceptible to jamming due to foreign matter in the tooth root.

IV MOUNTING ERRORS

To assure proper alignment and ease of final assembly, the ideal or basic relationship was established for each mating part and sub-assembly. A careful study of the tolerances that could reasonably be held by average good screw machine, jig borers and stamping operations, etc. was conducted. The sum of the related tolerances was distributed by either trimming or increasing the basic size as required for the ideal final alignment.

Allowing for standard machine hunting and cycling, the following type of fit was established and strictly maintained:

<u>Gear/Pinion (Ring Stake)</u>

Fit: .0002 inch minimum interference to
.0015 inch maximum interference

<u>Escapewheel/Pinion (Pressfit)</u>

Fit: .0005 inch minimum interference to
.0017 inch maximum interference.

<u>Pillar Post/Plate (Roll-over Stake)</u>

Fit: .001 inch maximum clearance to
.0002 inch maximum interference.

<u>Balance Shaft/Balance Mass (Pressfit)</u>

Fit: .0006 inch minimum interference to
.0018 inch maximum interference.

<u>Pinion and Arbor Pivots/Plate Pivot Holes (Clearance)</u>

Fit: .0007 inch minimum clearance to
.0019 inch maximum clearance.

<u>Impulse Pin/Balance Mass (Pressfit)</u>

Fit: .0004 inch minimum interference to
.0014 inch maximum interference.

In like manner, space was provided between adjacent components allowing more clearance for parts which either function or are free to move axially e.g., the click and the hairspring.

After establishing the ideal tolerances and clearances, proof sheets were prepared for each mating sub-assembly. These proof sheets, which contained a sketch of the fit being analyzed and computations used to prove the established end results, were bound in one volume and submitted with Report No. 9.

V MOUNTING PLATES

A. After repositioning the pillar posts as previously explained, varying plate thicknesses and pillar post configurations were subjected to a 6, 8 and 10 foot free fall on a 1/4 inch steel plate backed up with 2 inches of concrete. Various types of staking were also used.

To avoid difficulties of corrosion and plating and to minimize difficulties in stamping the plates, only brass plates and posts were planned for final use and therefore was the only material tested.

A plate thickness of .032 inch withstood the shock, but plates with a thickness of .025 inch became distorted at the post locations. For a margin of safety, and being reminded of the inadequate support resulting from the previous contractor, it was decided to use .040 inch thick material for the balance of the planned testing.

The second phase of this series of tests was to determine the best post dimensions and type of stake. It was found that properly executed, the type of stake made no significant difference under the conditions specified for the standard five foot free fall drop test.

B. A series of tests were conducted to determine what affect countersinking and surface micro-finish of the pivot holes would have on the beat rate. It was found that neither poor surface finish nor countersinking had any significant affect. These results were reflected in the drawings by the loosening of the required surface finish and making pivot hole countersinking advisory rather than mandatory.

Although die stamped pivot holes were not tested due to the lack of funds, .015 inch diameter holes have been satisfactorily pierced in .025 inch brass stock with an 8 finish. Completely stamped plates are recommended.

VI <u>STAKING OF SUB-ASSEMBLIES</u>

Although all types of staking punches proved satisfactory, the continuous, as opposed to the interrupted stake, was found to be the least complex to design and manufacture, required less aligning or registering in both tooling and performance and, in our study, had the lowest reject level.

The types of stake employed (by assembly) were:

(1) Plate No. 1 and Post Assembly - Continuous roll-over stake.

(2) Pinion and Gear Assembly - Continuous ring stake.

(3) Pallet Lever Assembly - Continuous ring stake.

(4) Arbor and Center Gear Assembly - Interrupted, registered stake.

(5) Plates No. 1 and 2 Assembly - Continuous ring stake.

(6) Plates No. 1, 2 and 3 Assembly - Continuous roll-over stake.

(7) Disc Assembly - Interrupted stake.

Where possible, a dual operating hold-down and stake method was used. This method provides a press down, a hold down, then the stake. Not one failure was found from among 10,000 stakes made using this method. Concentricity and perpendicularity requirements were also easily maintained.

VII <u>LUBRICATION</u>

The original intention was to design an unlubricated movement assembly. However, test results from tests conducted on the preliminary engineering test samples indicated a loss in beat rate at -65°F. Although the loss was still within the required accuracy, it was decided to minimize the loss if not eliminate it.

If was first thought that the problem would be solved by changing the mainspring torque, hairspring material, pivot hole center distances and the surface finish of some or all of the bearing surfaces. Different surface finishes, mainspring torque and hairspring material were tested under low temperature conditions. Also, contraction of the parts due to their respective temperature coefficients was calculated and center distances changed. However, the loss of beat rate persisted.

These failures prompted a study of various lubricants. The first indication that the lack of lubricity was the cause of the beat rate loss was obtained during tests of a newly fabricated self-starting and operating torque test fixture. Repeated tests of unlubricated movement subassemblies in this fixture indicated a beat rate pattern which approximated those obtained at -65°F. Apparently, metal to metal contact resulted in an increased galling action at successive tests of the same movement assembly. An intensive study of available dry and wet lubricants and various plating materials resulted. A dry lubricant, * "Vydax" AR, a flourocarbon telomer dispersion, was found to be the most satisfactory lubricant considering functioning, ease of application, and shelf life and was specified on the final design. The lubrication study is contained in Section VII of this report.

* "Vydax" is a registered trademark of E. I. DuPont de Nemours and Co., Inc., Wilmington 98, Delaware.

SECTION IV

DIFFICULTIES ENCOUNTERED AND HOW RESOLVED

DIFFICULTIES ENCOUNTERED

1. Balanced pallet lever
2. Mainspring torque
3. Gearing
4. Manufacture of escapewheel and center arbor
5. Objective measurement of small area micro-finishes
6. Staking of center arbor assembly
7. Lubrication

HOW DIFFICULTIES WERE RESOLVED

1. Balanced pallet lever. After theoretically computing the center of gravity for the pallet lever as well as making large scale wood and brass models, the actual final assembly still required experimental trimming. This was accomplished by the .087" radius which theoretically was a .100" radius.

Due to extreme assembly difficulties encountered, this pallet die was modified to incorporate the guard lever and various changes in radii were needed to again achieve a balanced assembly.

2. Mainspring torque. Procurement of mainsprings with the required "actual" torque output was found difficult without specifying all parameters directly on the drawing

e.g., physical dimension, heat treat procedure and final mechanical properties.

Unprecedented is a timer which is unaffected by intermittent 9 oz. in loading. Since the mainspring is an essential factor and conflicting test results were obtained, a mainspring torque testing fixture was designed and built. This fixture is included in Test Equipment Concept Sketches.

3. Gearing. Although both involute and cycloidal gearing proved satisfactory, this project was not without its gearing difficulties. Cold flow out the tip of the tooth was encountered with the cycloidal form during the first phase of finding limits of torque carrying ability. The material was changed from carbon steel to a heat treatable 416 S/S. Although cold flow stopped, fracture resulted due to insufficient beam strength. The cycloidal tooth was then modified by adding width and reducing tip interference by introducing a 1/2 ogive. These modifications coupled with a simply obtained hardness of 42 to 48 RC showed no signs of failure in 2,000 pinions used.

In the search for improved load carrying ability of paired gears, the involute long and short addendum system was tried. Although this profile is a more substantial tooth, the advantage is lost by the need for a higher precision.

Gears were a precision 1, pinions were both made from drawn stock and cut from blanks. Drawn pinions were separated in the commercial ranges of 2, 3 and 4 and the cut pinions were precision 1. Due to the bulby nature normally found existing in drawn pinion stock, however, satisfactory involute action was unobtainable. When centers were reduced there was jamming or lock-up, when centers were increased, there was insufficient depth of engagement. The involute precision 1 gears and pinions performed most satisfactorily. Involute versus cycloidal beat rate results are shown in Report No. 14. As cut pinions are much more expensive than drawn pinions, cycloidal gearing was chosen for the first design.

The main features of the two gear types are:

Cycloidal

The curvature of one tooth rolls on the outside of another (epicycloid), the curvature rolls on the inside of another circle (hypocycloid). The theory being that the circumference of one circle rolls, without slippage, over a curved surface. Thus the min. max. torque phase variation in cycloidal gearing is less than that which is inherent in involute action.

The cycloid form allows considerable backlash or clearance between teeth. For a uni-directional gear train such as this, backlash does not influence functioning.

Involute

Involute profiles slide upon each other over their entire path of engagement. The "sterling quality" of this system is that a change in center distances will not effect the velocity ratio. During the operation of involute gear trains, the periodic coincidence of cumulative errors causes a constant cycling of min. max. torque phases due to the resulting friction. In conventional "gearing down" applications there is unlimited power to overcome such frictions as well as the resistance due to viscous drag of a wet lubricant. In mainspring driven "gearing up" applications, however, power may be inadequate to overcome cumulative friction in addition to overcoming inertia.

Starting failures, arising from improper involute profile which is normal in gears having less than 21 teeth, can be avoided by increased pinion diameter and either a corresponding decrease in the gear diameter or an increase in center distance.. This addendum correction is less efficient when "gearing up" because, due to friction, the resultant line of thrust is inclined toward the driven member and could be self locking.

These are added reasons for our conclusion that the generous clearances inherent in cycloidal design would impose fewer problems for mass production than would the small clearances inherent in involute gearing.

4. Manufacture of escapewheel and center arbor. Extreme difficulties were encountered in the manufacture of the escapewheel until the need for the conventional close tolerances was studied. As a result of this study the following tolerances were relaxed.

tooth width .0226 - .0004 to .0224 - .0012

draw angle 5° + 2° to 6° + 4°

surface micro-finish 16 to 32

This relaxing of tolerances suggested the feasability of a die stamped part. This approach was pursued and proven satisfactory by test as shown in monthly Report No. 21.

Manufacture of the center arbor protrusion which engages the mainspring was attempted both from a swaging and shaving approach. Swaging, although inexpensive, left much to be desired as a margin of safety against fracture from unrelieved stresses and plastically deformed crystal grain structure. Shaving was accomplished in sections to avoid distortion or scoring of the supported arbor. The protrusion or dog remains entirely unstressed with no danger of fracture when placed under maximum stress conditions.

5. Objective measurement of small area micro-finishes. At the urging of Picatinny engineers, emphasis was placed upon a careful study of surface micro-finishes to expedite inspection. Tests showed that considerable relaxing could be tolerated with safety However, relaxed tolerances could be dangerous if supporting objective instrumentation were

unavailable for confirmation of visual data. The supply of adequate instrumentation is scarce but our difficulties were resolved when our search uncovered a Micrometrical Proficorder. No difficulty is encountered when measuring small areas.

6. Staking of center arbor assembly. Staking techniques studied early in this project went far toward avoiding staking difficulties during the various manufacturing phases. Staking and registering of the click to the center arbor was the only staking difficulty encountered. Registration of the stake in each corner of the click is necessary to prevent slippage or backlash which could influence the rate of the output shaft.

The cause of the difficulty was that insufficient metal was cold-flowed over the click and the hold was insecure. This was corrected by reducing the arbor clearance inside the punch and by decreasing the angle of the eight stake interrupted punch from 30° to 15°. Proper registering was accomplished through the use of alignment studs for the gear. The alignment studs provide recepticles for the four click drivers. By means of a keyway, the interrupted punch is registered to these four gear alignment studs.

7. Lubrication. Although unlubricated movements meet requirements within the first 1 1/2 revolutions, much was desired as a margin of safety due to loss of beat rate at

-65°F. The result in an intensive wet and dry lubrication study was the finding of a most satisfactory dry lubricant, "Vydax" AR, a flourocarbon telomer dispersion, thereby achieving a considerable margin of safety.

Lubrication test results are included in a special document called "Lubrication Study", which is contained in Section VII of this report.

SECTION V

TEST DATA

The following data are the results of tests conducted on a typical P.E. T5E1 Movement Assembly.* The output was regulated to 96 seconds per revolution to emphasize deviations at successive turns from full wound.

Mainspring Driven

Rev. from full wound	Amplitude deg/beat	Output Rate sec/rev
0	185	96.00
1/2	180	96.00
1	180	96.00
1 1/2	180	96.00
2	175	96.00
2 1/2	175	96.00
3	170	95.99
3 1/2	170	95.97
4	160	95.95
4 1/2	145	95.90
5	135	95.82
5 1/2	110	95.74

* Test data of typical movements tested over the temperature range -65 to + 160°F are reported in, Lubrication Study Section VII of this report.

This regulated movement had the mainspring removed and a one inch radius pulley was fitted to the output shaft. Using a string and weights the following data resulted.

Weight Driven

Torque ounce inches	Amplitude deg/beat	Output Rate sec/rev
4	90	95.79
6	110	95.84
8	125	95.85
10	135	95.89
12	165	95.89
14	170	95.88
16	185	95.88
18	190	95.86
20	200	95.85
22	210	95.81
24	215	95.80
26	220	95.78
28	225	95.77
30	230	95.76
32	240	95.75
34	250	95.73
36	255	95.72
38	260	95.71
40	265	95.69

The effect of various loads upon the beat rate at various revolutions from full wound was studied on a movement which had completed many cycles during the lubrication study. Results are listed below.

Load Tests

Rev. from full wound	Applied load oz. in.	Output Rate sec/rev
1	0	95.87
	9	95.87
2	0	95.87
	12	95.84
3	0	95.89
	9	95.84
4	0	95.90
	9	95.79
5	0	95.89
5 1/2	0	95.79

SECTION VI

CONCLUSIONS

The performance of this Production Engineered Movement Assembly proves that a detached pin lever escapement, of size suitable for incorporation in a fuze, and of a grade of manufacture suitable for mass production, can have high starting reliability; is unaffected by changes in torque and position; does not require selective assembly and has only 1/10 the timing error of the R&D Design.

Having achieved these performance objectives, a new standard was established for mass-produced timer reliability and repeatability.

This P.E. Design is simple, inherently rugged and inexpensive. These being desirable attributes in an ordnance item it is recommended that it be adapted to other weapons systems where a timing movement is used.

SECTION VII

LUBRICATION STUDY CONDUCTED FOR MOVEMENT ASSEMBLY MT, 90 SECOND, T3E2, T4E1 & T5E1 FOR MECHANICAL TIME BOMB FUZES

This lubrication study was undertaken to achieve a consistent output rate, repeatable within $\pm$ .5% over the temperature range -65 to +160°F.

Although unlubricated movement assemblies met these requirements, an improved margin of safety was sought per the "Scope of Work", Appendix A:

2. Provisions Applicable to Requirements

(2) The movement shall have an accuracy equal to or greater than $\pm$ .5% of the set time over a temperature range of -65°F to +160°F.

(7) Consideration shall be given to the material used so that a shelf life requirement of 10 years minimum, 20 years desired, may be attained.

Discussions with the Arsenal Project Officer concluded that this margin of safety be improved by an evaluation of available lubricants. A wet lubricant, G.E. SF 81 (20) was experimentally selected as a control against which to compare deviations. A stable reference was needed for the following reasons:

1- The beat rate of an unlubricated movement assembly varies approximately ± .5% over the first three revolutions from full wound. This variation reflects a change in torque transmission caused by a galling action or shearing of minute welds between escapewheel teeth and pallet pins.

2- The gearing mode of progression is one of gearing up, with a corresponding decrease in torque. Inevitable manufacturing errors produce an unavoidable periodic coincidence of minimum torque phases. As the mainspring torque decreases, stoppage occurs during one of these coincidences.

3- A further torque restriction is caused by the large changes in momentum as the train comes to fifty dead starts and stops per second. Metal to metal osculatory action between the escapewheel impulse face and pallet pins also restricts torque.

Various platings showed no decrease in the clinging nature of these parts (except Electrolizing). Believing that the main restrictions of torque originated from two sources, the first being surface roughness, led to the first abortive test results of mirror finished surfaces. The second source was believed to be the fact that opposing forces under extreme sliding conditions tend to create minute welds or galling on contact surfaces.

Although this welding of surfaces showed no signs of seizure, the force required to shear these infinitesimal welds severely reduced the transmission of torque to the spring-mass system.

Recognizing that seizing between a pair of sliding bodies, when separated by a pliable film, is greatly diminished, selected for testing were; dry anti stick-slip agents, various low viscosity oils in the range of 5 to 75 centipoise (water = 1 centipoise) and several high viscosity oils and greases.

Although lubricants requiring special application processes were avoided, Electrofilm, Electrolizing and Molykote were included due to their popularity.

The pre-requisite for efficient hydrodynamic action of a wet lubricant is not present in a clock-like escapement design. Therefore, the excellent performance of G.E. SF 81 (20) and Nyes' Special low temperature oil were noteworthy.

Hydrodynamic lubrication takes place in a closed journal bearing system due to a certain freedom of motion which allows oil to be pumped into clearances by high and low pressure areas. Escapement pallet pin and escapewheel tooth action has insufficient freeness of motion to be lifted from each other by either a wedge-shaped oil film or from a differential pressure within a closed system.

Inasmuch as an escapement design does not meet the ideal requirements for hydrodynamic lubrication but is rather an open rigid system, this study includes certain dry lubricants and anti stick-slip materials which adhere through bonding. Two such materials were offered by Picatinny Engineers and one of these, * "Vydax" AR, a flourocarbon telomer dispersion, proved to be most successful. Lithium stearate, unless carefully applied, entrapped fluid under a dry surface. At -65°F, heavy deposits in the root of gear teeth caused failure.

Except where otherwise specified, cycloidal gearing was used in all test movements. Government tooling, incorporating this gear type, was available and is specified on the final drawings.

<u>MOVEMENT QUALIFICATION TESTS</u> (Lubricated)

To ensure that this data truly reflect properties of the tested lubricant, the test movements were adjusted for uniformity of performance.

First tests conducted at -65°F with pulley, string and weights proved erratic. Investigation showed a freezing together of the string and pulley. This difficulty was overcome by treating both the string and pulley with "Vydax" AR.

* "Vydax" is a registered trademark of E.I. DuPont de Nemours & Co., Inc., Wilmington 98, Delaware.

These adjusting and qualifying tests, requiring repeated testing, were conducted on movement assemblies which were lubricated with G.E. SF 81 (20) to avoid dimensional changes due to wear.

Absolute driving torque was ensured through the use of a series of weights totalling 18 ounces.

Test Movement No. 1

OZ.IN. Absolute Torque	Output Rate sec/rev. +76°F	+160°F	-65°F
18	95.71	95.82	95.74
16	95.71	95.84	95.83
14	95.74	95.86	95.84
12	95.75	95.88	95.81
10	95.76	95.91	95.91
8	95.76	96.03	95.98
6	95.81	96.26	96.09
4	95.97	96.67	96.37

Test Movement No. 2

OZ.IN. Absolute Torque	Output Rate sec/rev. +76°F	+160°F	-65°F
18	95.93	95.93	95.89
16	95.93	95.93	95.87
14	95.91	95.93	95.86
12	95.90	95.92	95.86
10	95.89	95.95	95.86
8	95.87	95.94	95.89
6	95.87	96.00	95.97
4	95.95	96.20	95.80

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MOVEMENT QUALIFICATION TESTS

Test Movement No. 3

OZ.IN. Absolute torque	Output Rate sec/rev. +76°F	+160°F	-65°F
18	95.84	95.87	95.89
16	95.85	95.88	95.90
14	95.85	95.88	95.91
12	95.84	95.87	95.91
10	95.83	95.86	95.95
8	95.83	95.84	96.07
6	95.78	95.83	96.29
4	95.87	95.85	96.96

Test Movement No. 4

OZ.IN. Absolute torque	Output Rate sec/rev. +76°F	+160°F	-65°F
18	95.93	95.91	95.85
16	95.92	95.90	95.85
14	95.91	95.88	95.83
12	95.88	95.81	95.80
10	95.86	95.79	95.78
8	95.83	95.74	95.76
6	95.78	95.71	95.76
4	95.96	95.69	95.90

MOVEMENT QUALIFICATION TESTS (Unlubricated)

Having qualified starting-operating and beat-rate performance, the complete movement assembly and mainspring were carefully cleaned, rinsed in *Freon and assembled completely dry.

* Freon is a registered trademark of E.I. DuPont de Nemours & Co., Inc., Wilmington 98, Delaware.

Mainspring torque readings, taken at the output shaft, were; 20 oz.in., 17 oz.in., 15.5 oz.in., 13.5 oz.in., 11 oz.in. and 8 oz.in. respectively/rev.

	Test Movement No. 1			Test Movement No. 2	
	Output Rate	sec/rev		Output Rate	sec/rev
Rev	+160°F	-65°F	Rev	+160°F	-65°F
1	95.83	96.14	1	95.97	95.93
2	95.86	96.10	2	96.07	95.97
3	95.93	96.00	3	96.20	96.05
4	96.13	96.20	4	96.58	96.14
5		96.67	5		96.16

	Test Movement No. 3			Test Movement No. 4	
	Output Rate	sec/rev		Output Rate	sec/rev
Rev	+160°F	-65°F	Rev	+160°F	-65°F
1	96.13	96.06	1	95.89	96.06
2	96.04	96.16	2	96.05	96.15
3	96.12	96.26	3	96.05	96.26
4	96.20	96.53	4	96.78	96.58
5		97.34	5		97.34

The output rates shown were converted from actual, recorded beat rates. Where no output rate is indicated, the beat rate recording showed no discernable pattern.

Upon completion of each hot - cold test, the mainspring was removed and everything carefully cleaned, rinsed in Freon and another wet lubricant properly applied.

Lubrication Study

DC 200 (50 cstks)			Astro Oil MIL-L-3918	
No. 1		Test Movement	No. 2	
Output Rate	sec/rev		Output Rate	sec/rev
+160°F	-65°F	Rev	+160°F	-65°F
95.66	96.04	1	95.99	Started
95.66	96.07	2	95.98	No Discern-
95.74	96.10	3	95.95	able beat
95.74	96.20	4	95.91	rate
95.87	96.67	5	95.87	

Lubrication Study

Nye's Spec. Low Temp. Oil No. 3		Test Movement	Watch Oil PML 92 No. 4	
Output Rate +160°F	sec/rev -65°F	Rev	Output Rate +160°F	sec/rev -65°F
95.80	95.95	1	95.89	Failed to
95.84	95.95	2	95.89	start
95.84	95.95	3	95.87	
95.84	95.95	4	95.87	
95.81	96.13	5	95.83	

Moebius Synt-a-lube OL-235 No. 1		Test Movement	Moebius Synt-a-Frigo-Lube OL-217 No. 2	
Output Rate +160°F	sec/rev -65°F	Rev	Output Rate +160°F	sec/rev -65°F
95.74	Started	1	96.00	Started
95.72	No discern-	2	96.00	No discern-
95.72	able beat	3	95.97	able beat
95.72	rate	4	95.93	rate
95.77		5	95.89	

Moebius Chronometer Oil No. 1 No. 3		Test Movement	Moebius Wrist Watch Oil No. 2 No. 4	
Output Rate +160°F	sec/rev -65°F	Rev	Output Rate +160°F	sec/rev -65°F
95.89	Failed to	1	95.87	Failed to
95.90	start	2	95.87	start
95.92		3	95.87	
95.92		4	95.87	
95.87		5	95.80	

Moebius Synt-a-Lube OL-216 No. 1		Test Movement	Longine Watch Oil LO-125 No. 2	
Output Rate +160°F	sec/rev -65°F	Rev	Output Rate +160°F	sec/rev -65°F
95.71	Started	1	96.00	Started
95.74	No discern-	2	95.99	No discern-
95.74	able beat	3	95.97	able beat
95.74	rate	4	95.93	rate
95.74		5	95.87	

Elgin M-56B Watch Oil No. 3		Test Movement	PD-764 MIL-L-17353 No. 2	
Output Rate +160°F	sec/rev -65°F	Rev	Output Rate +160°F	sec/rev -65°F
95.90	Failed to	1	95.90	96.02
95.92	start	2	95.90	95.99
95.92		3	95.89	96.02
95.92		4	95.86	96.02
95.86		5	95.78	96.00

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Lubrication Study

Test Movement

PA-22344 MIL-L-11734 No. 1 Output Rate +160°F	sec/rev -65°F	Rev	G.E. SF-81 (50) No. 2 Output Rate +160°F	sec/rev -65°F
95.66	Started	1	95.98	95.93
95.70	No discern-	2	95.95	95.92
95.70	able beat	3	95.93	95.92
95.74	rate	4	95.90	95.91
95.82		5	95.83	95.97

Test Movement

G.E. F-50 No. 3 Output Rate +160°F	sec/rev -65°F	Rev	G.E. SF 96 (50) Silicone Fluid No. 4 Output Rate +160°F	sec/rev -65°F
95.89	Started	1	95.95	95.95
95.89	No discern-	2	95.93	95.89
95.87	able beat	3	95.89	95.89
95.87	rate	4	95.86	95.89
95.84		5	95.74	96.34

Test Movement

G.E. F-30 No. 1 Output Rate +160°F	sec/rev -65°F	Rev	Winsor Lube LS-172 No. 2 Output Rate +160°F	sec/rev -65°F
95.70	96.05	1	95.96	95.87
95.72	96.00	2	95.95	95.89
95.72	95.98	3	95.92	95.89
95.72	96.00	4	95.90	95.87
95.80	96.67	5	95.83	95.80

Test Movement

Winsor Lube LS-252 MIL-L-17353 No. 3 Output Rate +160°F	sec/rev -65°F	Rev	Dow Corning 510 500 cstks No. 4 Output Rate +160°F	sec/rev -65°F
95.90	95.90	1	95.90	97.13
95.91	95.89	2	95.87	97.13
95.91	95.89	3	95.80	
95.89	95.89	4	95.77	
95.86	95.89	5	95.66	

Test Movement

Anderol L-423 Low Temp. Oil No. 1 Output Rate +160°F	sec/rev -65°F	Rev	Union Carbide L-45 Silicone No. 2 Output Rate +160°F	sec/rev -65°F
95.66	95.70	1	95.93	95.86
95.66	95.70	2	95.92	95.84
95.66	95.70	3	95.91	95.84
95.68	95.80	4	95.99	95.83
95.84	95.84	5	95.89	95.76

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Lubrication Study

G.E. SF-96 (500) Silicone Fluid No. 3		Test Movement	G.E. Versilube (R) F50 Silicone Fluid No. 4	
Output Rate +160°F	sec/rev -65°F	Rev	Output Rate +160°F	sec/rev -65°F
95.90	Started	1	95.89	Started
95.89	No discern-	2	95.91	Rate too
95.91	able beat	3	95.91	slow to
95.89	rate	4	95.89	record
95.80		5	95.78	

G.E. SF-96 (10) Silicone Fluid No. 1		Test Movement	G.E. SF-96 (5) Silicone Fluid No. 2	
Output Rate +160°F	sec/rev -65°F	Rev	Output Rate +160°F	sec/rev -65°F
95.71	95.52	1	95.91	95.86
95.66	95.52	2	95.91	95.83
95.66	95.52	3	95.90	95.83
95.74	95.60	4	95.88	95.83
95.89	95.60	5	95.83	95.80

G.E. SS 4005 Silicone Dielectric Grease No. 3		Test Movement	Anderol L-419 Thixotropic Grease No. 4	
Output Rate +160°F	sec/rev -65°F	Rev	Output Rate +160°F	sec/rev -65°F
95.95	Started	1	95.90	96.96
95.95	No discern-	2	95.89	96.40
95.95	able beat	3	95.89	96.20
95.89	rate	4	95.89	96.07
95.97		5	95.80	96.03

Anderol L-730 No. 1		Test Movement	DuPont "Block" No. 2	
Output Rate +76°F	sec/rev -65°F	Rev	Output Rate +76°F	sec/rev -65°F
95.98	95.91	1	95.73	Failed to
95.98	95.91	2	95.73	start
95.97	95.90	3	95.80	
95.96	95.90	4	95.80	
95.93	95.89	5	95.87	

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Dry Lubricants and Plated Finishes

This section deals with various dry lubricants and plated metal finishes. Each of these tests was conducted on separate movement assemblies to avoid misleading test results.

Rev	Electrolizing Output Rate sec/rev −65°F	Electrolizing +76°F	Electrolizing +160°F	Electrofilm Output Rate sec/rev −65°F	Electrofilm +160°F
1	95.80	95.95	96.00	95.93	95.93
2	95.74	96.00	95.95	95.96	95.93
3	95.86	96.06	95.93	95.98	95.93
4	95.38	96.14	95.86	96.00	95.93
5		96.67	95.86	95.95	95.93

Both Electrolizing and Electrofilm increase pivot OD and significantly decrease bearing ID. Care was exercised not to plate bearing holes and pivots were burnished back to a middle tolerance dimension.

Rev	Poxylube-420 Output Rate sec/rev −75°F	Poxylube-420 +76°F	Poxylube 750 Output Rate sec/rev −75°F	Poxylube 750 +76°F
1	95.71	95.80	95.62	95.85
2	95.71	95.80	95.62	95.85
3	95.66	95.80	95.62	95.85
4	95.66	95.80	95.71	95.85
5	95.62	95.80	95.80	96.00

Rev	Molykote PVE-K 250 Output Rate sec/rev −75°F	Molykote PVE-K 250 −65°F	Molykote PVE-K 250 +76°F	Molykote M 88 Output Rate sec/rev −75°F	Molykote M 88 −65°F	Molykote M 88 +76°F
1	No discernable beat rate	95.76	96.00	95.80	95.80	95.86
2		95.76	96.00	95.80	95.80	95.86
3		95.76	96.10	95.80	95.80	95.86
4		95.76	96.14	95.80	95.80	95.86
5		95.95	96.19	95.80	95.80	95.86

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Dry Lubricants and Plated Finishes

Molykote G

Output Rate sec/rev			
-75°F	-65°F	+76°F	Rev
Failed	95.80	95.95	1
to start	95.80	95.95	2
	95.80	95.93	3
	95.86	95.90	4
	95.86	95.90	5

Molykote Type V

Output Rate sec/rev		
-75°F	-65°F	+76°F
Failed to start		95.95
		95.95
		95.95
		95.93
		95.90

Molykote M-880

Output Rate sec/rev			
-75°F	-65°F	+76°F	Rev
95.80	95.90	95.86	1
95.80	95.90	95.86	2
95.80	95.90	95.86	3
95.80	95.86	95.86	4
95.76	95.86	95.86	5

"Vydax" AR

Output Rate sec/rev		
-75°F	-65°F	+76°F
95.87	95.93	95.93
95.87	95.93	95.87
95.87	95.86	95.87
95.87	95.86	95.87
95.80	95.81	95.87

The following are 76°F output rates listed in sec/rev for different movements lubricated with "Vydax" AR picked at random from among the Production Quantity. The direction of change from the first to the fifth revolution was of interest to determine consistency of "Vydax" AR deposited on components from the simple dip process used.

Rev	1	2	3	4	5	6	7
1	95.99	96.00	96.00	95.97	95.89	95.96	95.89
2	95.93	96.00	96.01	95.95	95.89	95.96	95.89
3	95.91	96.01	96.02	95.93	95.89	95.96	95.87
4	95.89	96.00	96.00	95.90	95.89	95.99	95.87
5	95.87	95.99	95.95	95.94	95.89	96.01	95.87

Rev	8	9	10	11	12	13	14
1	95.96	95.99	95.90	95.92	95.77	95.92	95.98
2	95.96	95.99	95.90	95.92	95.77	95.92	95.98
3	95.93	95.97	95.90	95.92	95.83	95.92	95.98
4	95.89	95.96	95.89	95.84	95.90	95.92	95.97
5	95.84	95.95	95.89	95.77	95.91	95.91	95.97

Beat rate influence from various points of friction

These tests were conducted to determine the extent to which the various friction points contributed to restricting transmission of torque. Test movement number 3 was used together with the respective mainspring used during the lubrication study.

Starting completely dry, G.E. SF 81 (20) was added to the following friction points in the order shown. Lubrication was not cumulatively added but rather was thoroughly removed after each friction point was tested.

Friction point(s) lubricated:		*BEAT RATE in %
1.	Dry output rate: 96.19 sec/rev	-.20
1.1	Escapewheel tooth impulse and locking angle only	+.18
1.2	Impulse pin only	+.14
1.3	1 & 2 only	+.18
1.4	Balance pivots only	+.15
1.5	Pallet pivots only	+.08
1.6	Escapewheel pivots only	+.11
1.7	4, 5 & 6 only	+.13
1.8	Center Arbor pivots only	+.13
1.9	Gear 1, 2 and escape pivots only	+.14
1.10	8 & 9 only	+.10
1.11	Center gear and pinion No. 1 only	+.14
1.12	Gear No. 1, Pinion No. 2, Gear No. 2 and escape pinions only	+.17
1.13	11 & 12 only	+.12
1.14	Mainspring only	+.17
1.15	Mainspring and all pivots only	+.15
1.16	Mainspring, all pivots, gears and pinions only	+.15
1.17	Mainspring, all pivots and impulse pin only	+.15
1.18	Mainspring, all pivots and escapewheel impulse and locking angles only	+.20
1.19	17 & 18	+.20

* 1% = 14.4 minutes/day

Consistency of torque transmission through involute gearing

When this lubrication study was deemed necessary, both cycloidal and involute gearing were being considered. Reason for considering both types was that cycloidal Government tooling was available and involute tooling are always standard "off-the-shelf" items.

Various lubricants were applied, only one lube per movement. The extra costs required to prepare special control movements were not warranted. This accounts for the random reporting which follows:

Lithium Stearate

Output Rate -65°F	sec/rev +76°F	Rev
96.67	95.93	1
96.23	95.93	2
96.40	95.96	3
96.54	95.97	4
96.67	96.00	5

DC 200

Output Rate sec/rev -65°F
96.06
96.06
96.12
96.12
96.19

"Vydax" AR

Output Rate sec/rev -100°F	Rev
96.19	1
96.19	2
96.19	3
96.19	4
96.19	5

Nyes' Low Temperature Oil

Output Rate sec/rev -65°F
96.19
96.09
96.00
96.19
96.19

G.E. SF 81 (50)

Output Rate sec/rev -65°F	Rev
95.95	1
95.95	2
95.95	3
95.93	4
95.90	5

Winsor Lube LS-172

Output Rate sec/rev -65°F
96.14
96.09
96.14
96.09
96.14

Life Tests

Life tests were conducted on two movements selected at random from among the 250 Production Quantity. One was lubricated with G.E. SF 81 (20) and the other with "Vydax" AR. After 200 revolutions of the output shaft both movements were conditioned for 2 hours at -90°F. Both incorporated cycloidal gearing.

G.E. SF 81 (20) Output Rate sec/rev	Rev	"Vydax" AR Output Rate sec/rev
95.93	1	95.93
95.91	2	95.93
95.86	3	96.00
95.86	4	96.05
95.81	5	96.07

These are beat rate results only and do not indicate variations in the rate of the output shaft.

Extreme difficulties were encountered in the manufacture of the escapewheel for this movement assembly. Tolerances were relaxed to determine the feasability of stamping the entire component rather than stamping only the blank then mounting them on an arbor and cutting the teeth.

The results were most satisfactory as the following comparison shows. "Vydax" AR was used in these tests.

Movement No. 10 Output Rate stamped and cut	Movement No. 10 sec/rev stamped only	Rev	Movement No. 11 Output Rate stamped and cut	Movement No. 11 sec/rev stamped only
95.92	95.91	1	95.98	95.97
95.92	95.91	2	95.97	95.97
95.92	95.92	3	95.95	95.96
95.97	95.92	4	95.93	95.95
95.92	95.92	5	95.92	95.92

Conclusions

Although friction, wear and lubrication has long been a subject of study as relates to the working of heavy machinery and motors, little has been published on experiments conducted with small mechanisms. Particularly those mechanisms having extremes of both high and low speeds with heavy specific shock accelerated loads.

These shocks being in the order of approximately 10 times greater than those experienced in mechanics, consideration was given dissimilarity of materials, their wear, elastic distortion, plastic compression and surface roughness and waviness.

Wear was minimized and elastic distortion contained within functionable limits through the selection of heat treatable materials. Plastic compression of bearing material is safe from seizure limits even under these heavy loads.

No matter how highly polished, surface roughness and waviness inevitably leaves an "apparent" surface contact which is greater than the actual contact surface. Thus, local pressures exerted are sufficiently amplified to affect even the crystal grain relationships. The result is plastic deformation of materials and the formation of minute welds or deposits as with a charged cutter.

ELECTRONIC Hairspring VIBRATING CO.
MECHANICAL CHEMICAL
Div of
TORQUE CONTROLS, INC.

The lubricity of a lubricant is its "film strength" or ability to carry these loads without rupture thus avoiding direct contact between solid surfaces, their deformation and ultimate "charging".

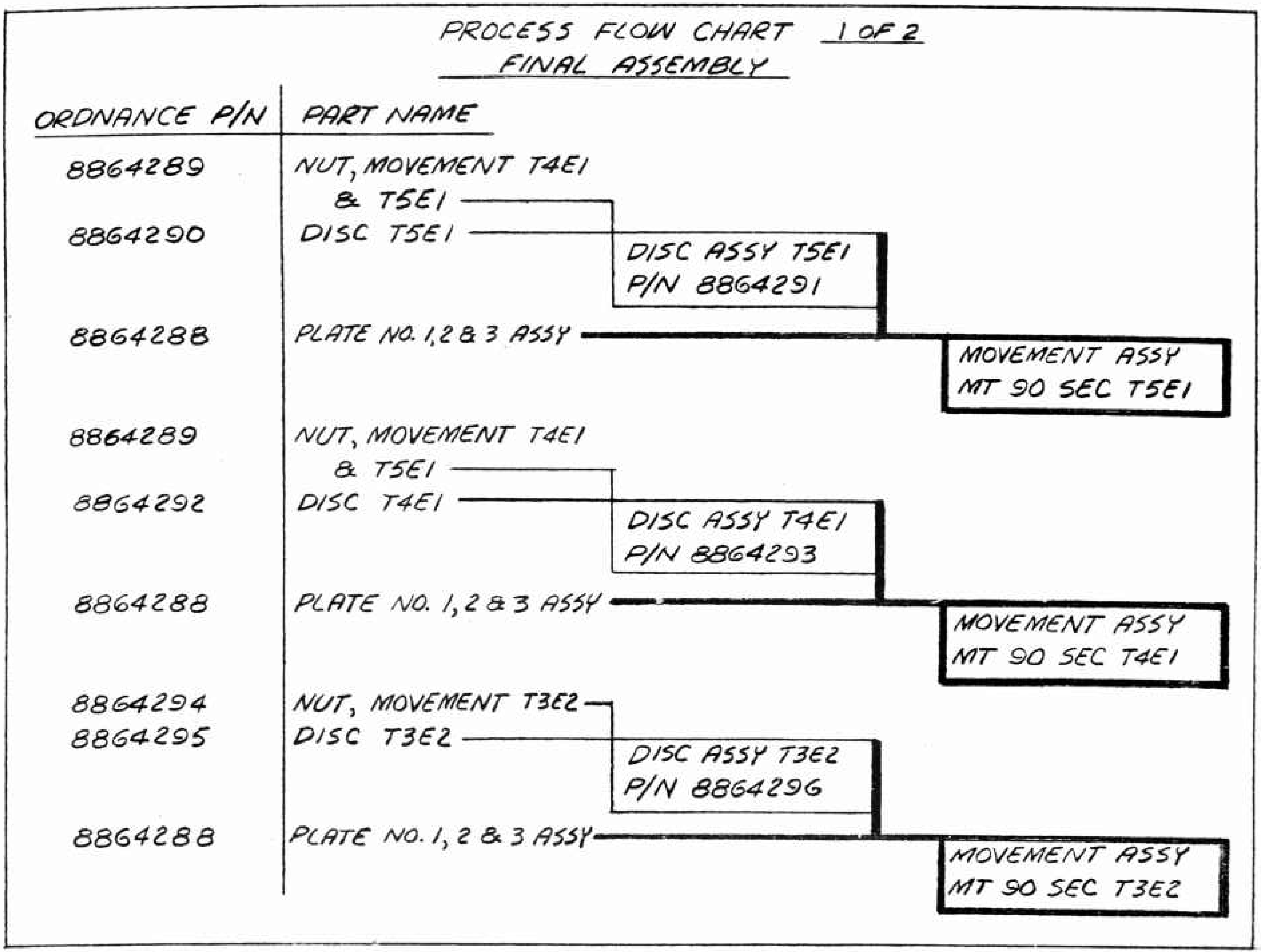
To best avoid this charging and possible seizure of sliding metal parts, it was concluded that the inevitable irregularity of surface finish be utilized. The search was thus narrowed down to finding an anti stick-slip material which, under pressure, would fill in the low spots and act as a lubricant reservoir.

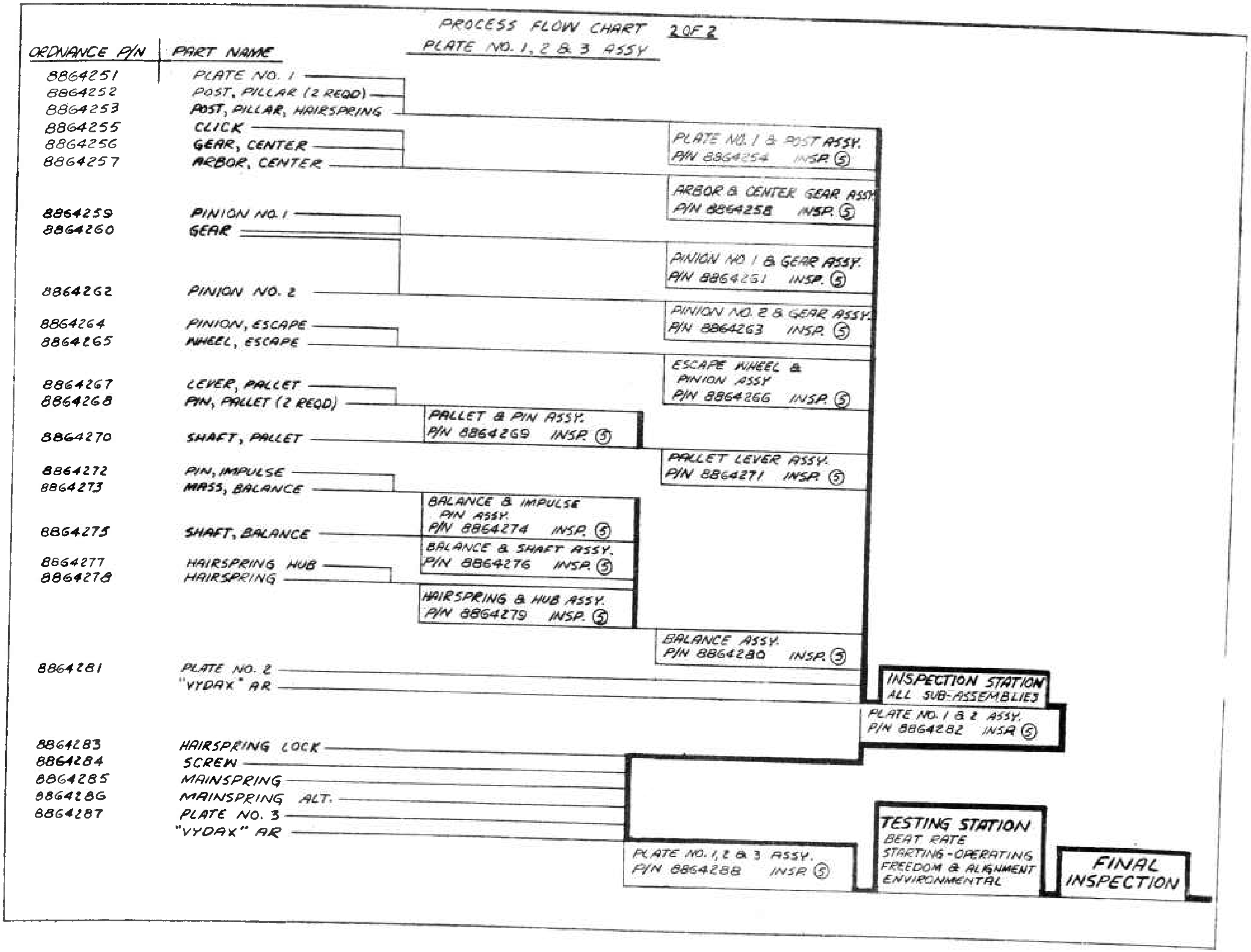
In addition to the test results, "Vydax" AR was selected because of:

1. Ease of application.
2. Least change in component dimensions after application.
3. Measured as consistency of beat rate, there is no discernable decay in its anti-charging property.
4. Being a dry film lubricant, shelf life is considerably enhanced.

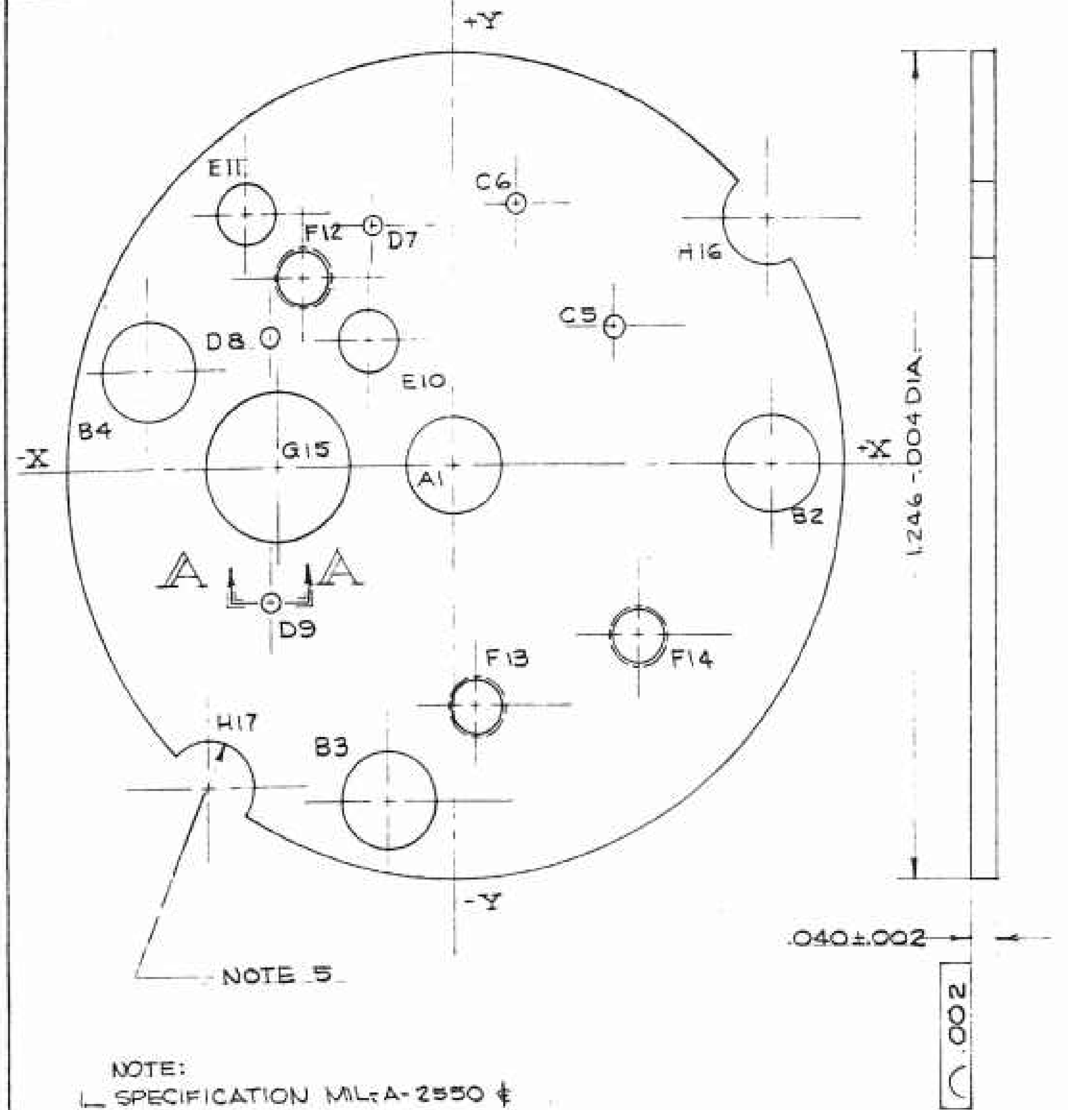
SECTION VIII

PROCESS FLOW CHART AND DRAWINGS

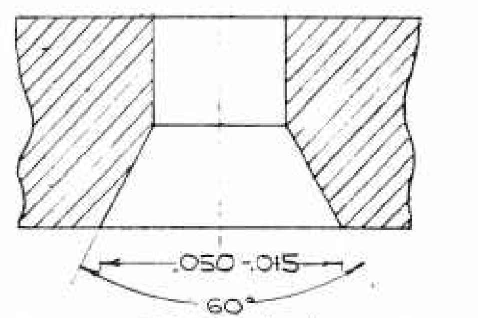

PROCESS FLOW CHART 1 OF 2
FINAL ASSEMBLY
ORDNANCE P/N
PART NAME
8864289
NUT, MOVEMENT T4E1 & T5E1
8864290
DISC T5E1
DISC ASSY T5E1 P/N 8864291
8864288
PLATE NO. 1,2 & 3 ASSY
MOVEMENT ASSY MT 90 SEC T5E1
8864289
NUT, MOVEMENT T4E1 & T5E1
8864292
DISC T4E1
DISC ASSY T4E1 P/N 8864293
8864288
PLATE NO. 1,2 & 3 ASSY
MOVEMENT ASSY MT 90 SEC T4E1
8864294
NUT, MOVEMENT T3E2
8864295
DISC T3E2
DISC ASSY T3E2 P/N 8864296
8864288
PLATE NO. 1, 2 & 3 ASSY
MOVEMENT ASSY MT 90 SEC T3E2



PROCESS FLOW CHART 2 OF 2
PLATE NO. 1, 2 & 3 ASSY
ORDNANCE P/N
PART NAME
8864251 PLATE NO. 1
8864252 POST, PILLAR (2 REQD)
8864253 POST, PILLAR, HAIRSPRING
8864255 CLICK
8864256 GEAR, CENTER
8864257 ARBOR, CENTER
8864259 PINION NO. 1
8864260 GEAR
8864262 PINION NO. 2
8864264 PINION, ESCAPE
8864265 WHEEL, ESCAPE
8864267 LEVER, PALLET
8864268 PIN, PALLET (2 REQD)
8864270 SHAFT, PALLET
8864272 PIN, IMPULSE
8864273 MASS, BALANCE
8864275 SHAFT, BALANCE
8864277 HAIRSPRING HUB
8864278 HAIRSPRING
8864281 PLATE NO. 2
"VYDAX" AR
8864283 HAIRSPRING LOCK
8864284 SCREW
8864285 MAINSPRING
8864286 MAINSPRING ALT.
8864287 PLATE NO. 3
"VYDAX" AR
PLATE NO. 1 & POST ASSY. P/N 8864254 INSP. 5
ARBOR & CENTER GEAR ASSY. P/N 8864258 INSP. 5
PINION NO 1 & GEAR ASSY. P/N 8864261 INSP. 5
PINION NO. 2 & GEAR ASSY. P/N 8864263 INSP. 5
ESCAPE WHEEL & PINION ASSY P/N 8864266 INSP. 5
PALLET & PIN ASSY. P/N 8864269 INSP. 5
PALLET LEVER ASSY. P/N 8864271 INSP. 5
BALANCE & IMPULSE PIN ASSY. P/N 8864274 INSP. 5
BALANCE & SHAFT ASSY. P/N 8864276 INSP. 5
HAIRSPRING & HUB ASSY. P/N 8864279 INSP. 5
BALANCE ASSY. P/N 8864280 INSP. 5
INSPECTION STATION ALL SUB-ASSEMBLIES
PLATE NO. 1 & 2 ASSY. P/N 8864282 INSP. 5
PLATE NO. 1, 2 & 3 ASSY. P/N 8864288 INSP. 5
TESTING STATION
BEAT RATE
STARTING-OPERATING
FREEDOM & ALIGNMENT
ENVIRONMENTAL
FINAL INSPECTION



HOLE DATA				
HOLE	DIA.	TZD ⌖AB	BASIC X	BASIC Y
A1	.1470 +.0005	-A-	DATUM	DATUM
B2	.1400 +.0005	.0016	.5143	DATUM
B3	.1400+.0005	.0016	-.0861	-.3073
B4	.1400+.0005	.0016	-.4917	+.1500
C5	.0280 +.0008	.0016	+.2614	-.2191
C6	.0280 +.0008	.0016	+.1066	+.3923
D7	.0245+.0008	.0016	-.1234	+.3594
D8	.0245+.0008	.0016	-.2938	+.1939
D9	.0245+.0008	.0016	-.2927	-.2066
E10	.100 +.005	.0020	-.1430	+.1860
E11	.100 +.005	.0020	-.3330	+.3796
F12	#3-56 NF-2B	.0016	-.2381	+.2827
F13	#3-56 NF-2B	.0016	+.0559	-.3655
F14	#3-56 NF-2B	.0016	+.2927	-.2582
G15	.281 ±.005	.0020	-.2800	.0000
H16	.0700+.0008R	.0016	+.5077	+.3633
H17	.0700+.0008R	.0016	-.3964	-.4828

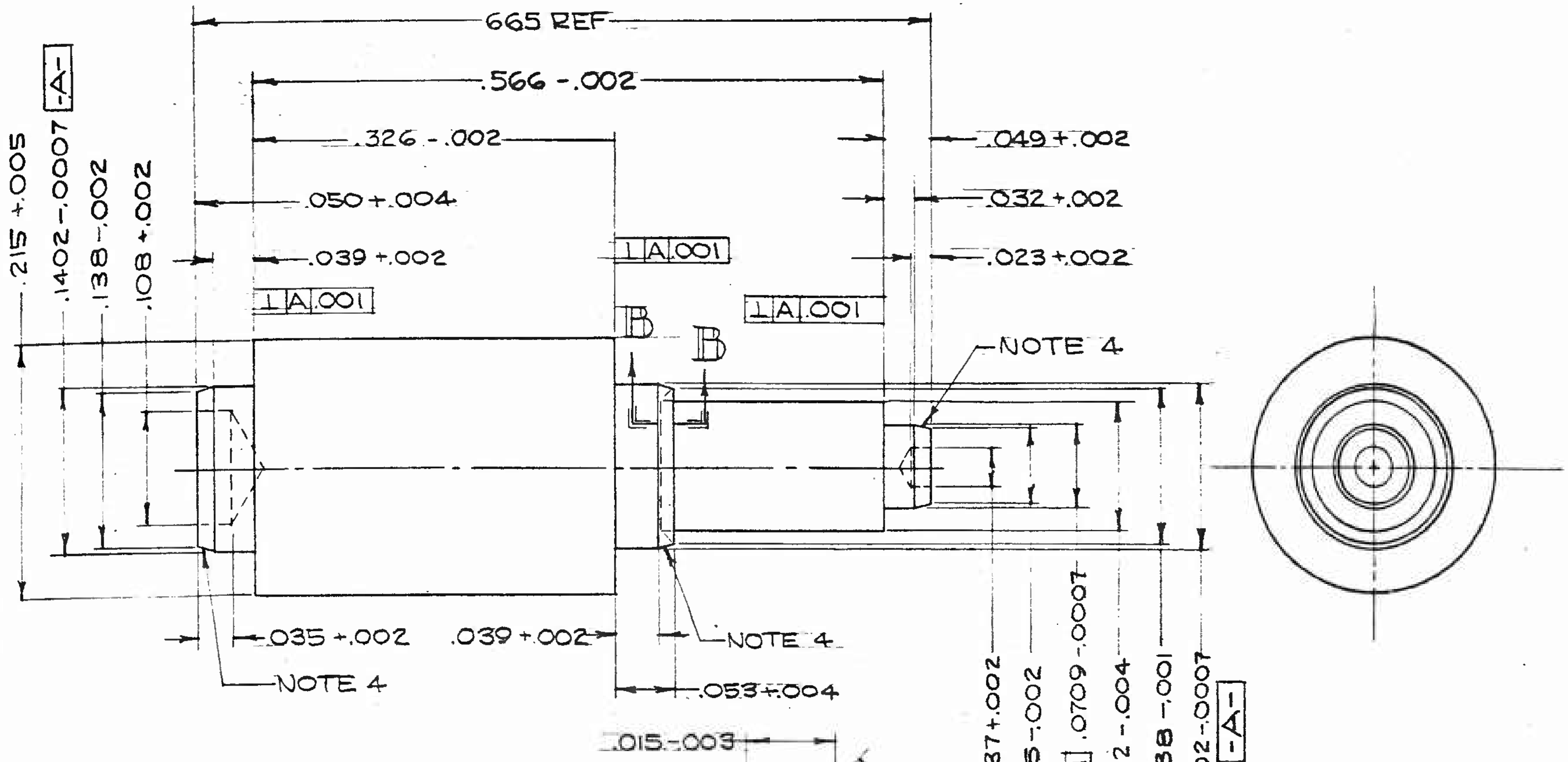


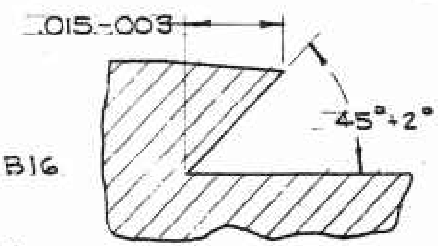
SECTION A-A SEE NOTE 4
HOLES C & D
SCALE 40/1

NOTE:
1. SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2. MATERIAL:- BRASS, STRIP, ½ HARD, ALLOY #5, SPEC ASTM B121
3. FINISH ALL OVER 125
4. ADVISORY:- SECTION A-A INDICATES METHOD FOR REDUCTION OF PIVOT FRICTION
5. ADVISORY:- CUTOUTS H16 & H17 FACILITATE AUTOMATIC ASSEMBLY TECHNIQUE.

NEXT ASSY 8864254		USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR AS.P.	SCALE 5:1	REVISION	DATE
CH			
APPR			
DATE 8/5/62			
TITLE PLATE #1		NO. 8864251	

HV-1



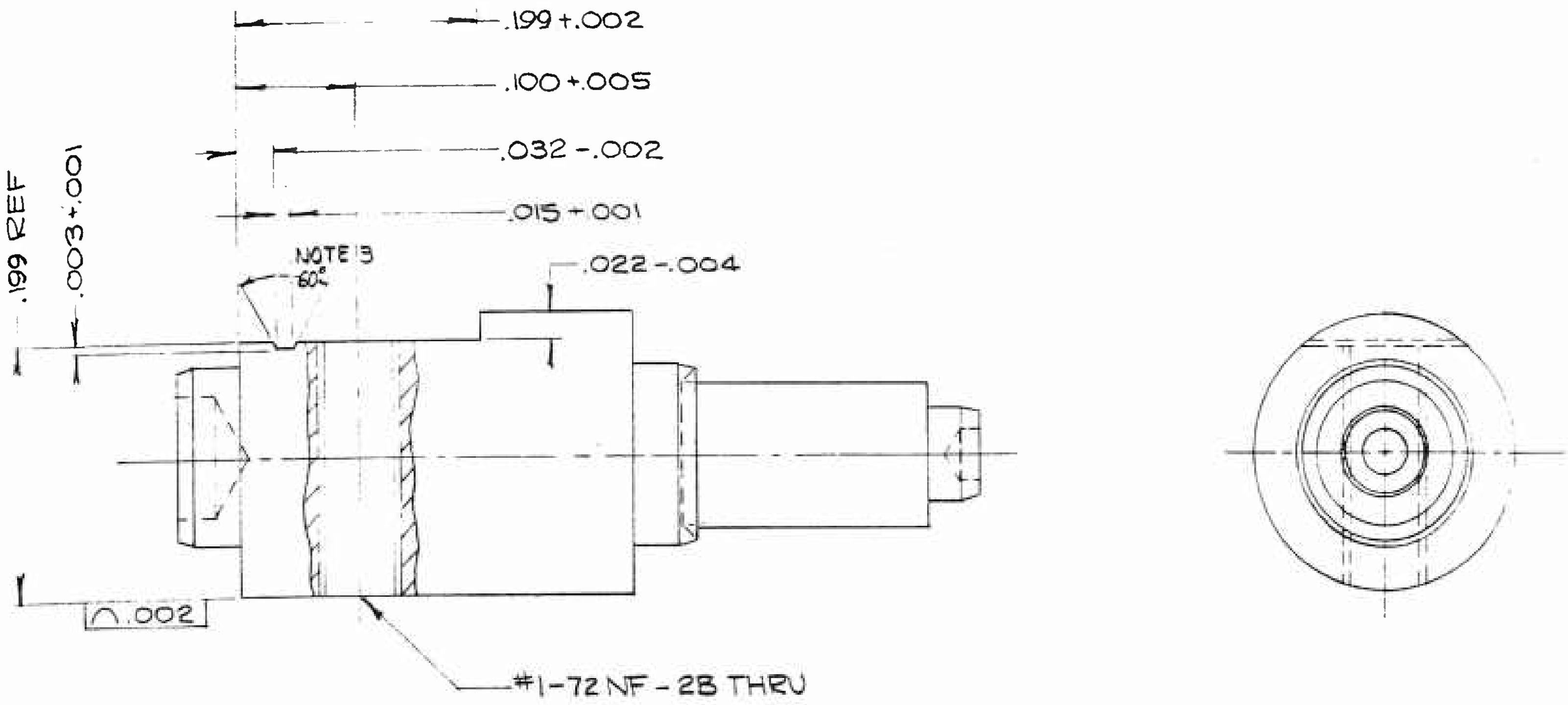


SECTION B-B
SCALE 50:1

NOTES:
1 - SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2 - MATERIAL: BRASS, ROD, SPEC ASTM B16
3 - FINISH ALL OVER 63
4 - ADVISORY: - TAPERS FACILITATE AUTOMATIC ASSEMBLY TECHNIQUES.

NEXT ASSY. 8864254		USED ON: T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A.S.P.	SCALE 0:1	REVISION	DATE
CH.			
APPR. CV			
DATE 9/7/62			
TITLE POST, PILLAR		NO 8864252	

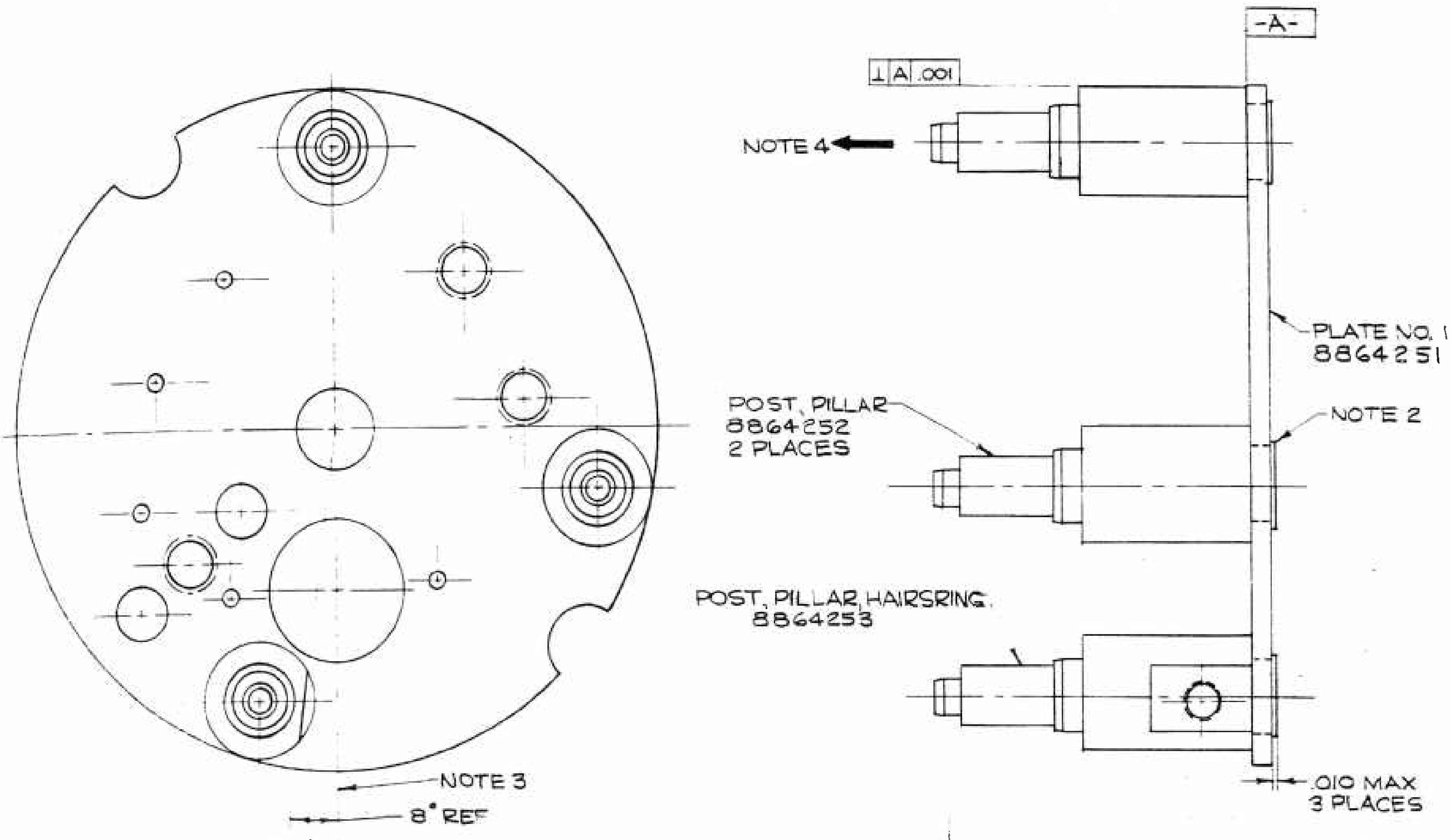
HV-2



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2- PART IS MADE FROM HV-2.
3- ADVISORY:-ANGLE FACILITATES HAIRSPRING ASSEMBLY

NEXT ASSY 8864254	USED ON. T3E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N J	
DR A.S.D. SCALE	REVISION DATE
CH	
APPR	
DATE 9/7/62	
TITLE POST, PILLAR, HAIRSPRING 8864253	

HV-3



NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.

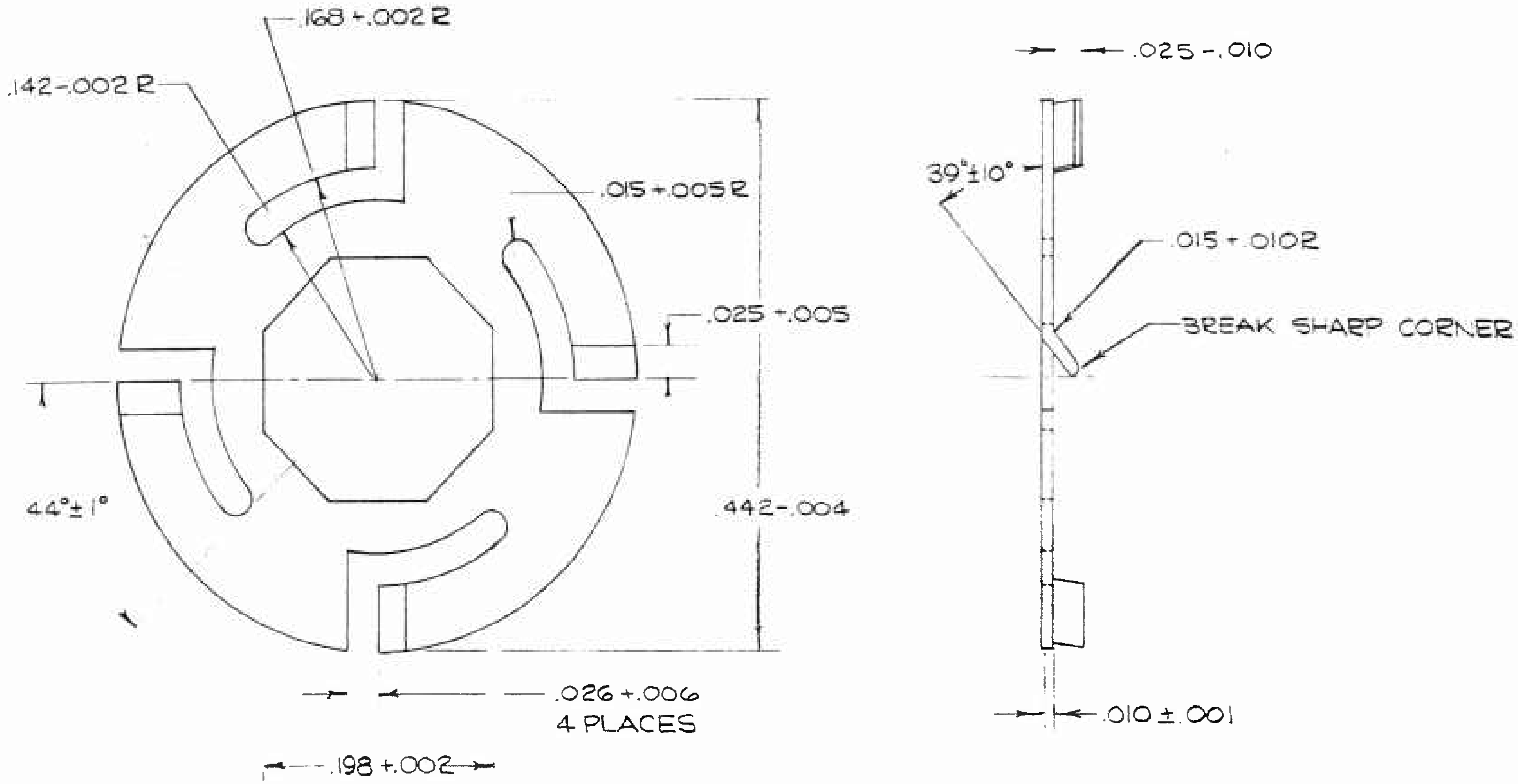
2- SECURE POSTS TO PLATE NO.1 BY ANY SUITABLE METHOD (SEE NOTE 4.)

3-THE FLAT ON HAIRSRING POST TO BE ORIENTED ALONG ANGLE "A".

4-EACH POST TO WITHSTAND A MINIMUM LOAD OF 25LBS. IN THE DIRECTION SHOWN WITHOUT ANY VISIBLE GAP BETWEEN THE PLATE & POST SHOULDERS.

NEXT ASSY 8864282	USED ON T5E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV OF TORQUE CONTROLS INC UNION CITY, N. J.		
DR A.S.P.	SCALE 3:1	REVISION / DATE
CH		
APPR		
DATE 9/7/62		
TITLE PLATE NO 1 & POST ASSEMBLY	NO. 8864254	

HV-4

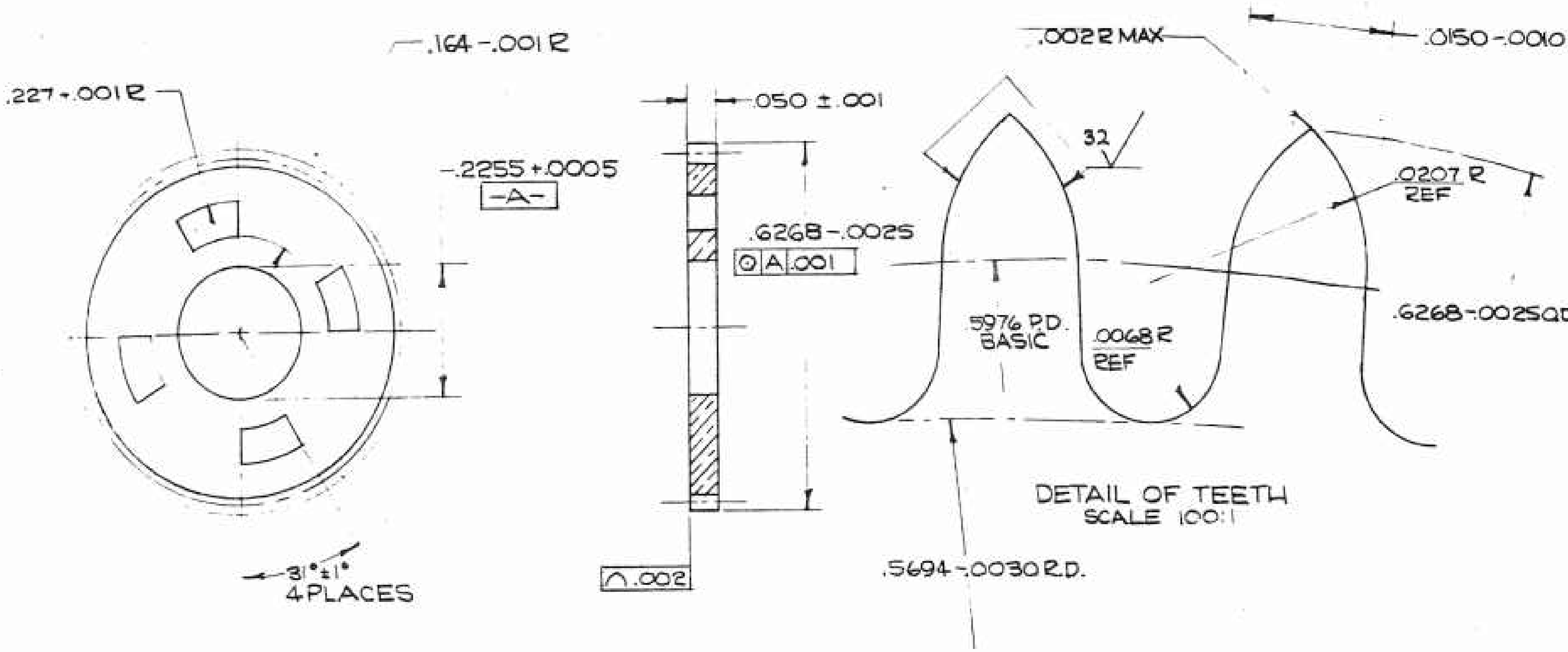


NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2- MATERIAL: STEEL, CARBON, STRIP, COLD ROLLED, UNTEMPERED SPRING, 1095 A. INTERMEDIATE TEMPER, R_{15t} 88-91, OAC-PD-109.
3- HEAT TREAT TO R_{15N} 84-86.
4- PROTECTIVE FINISH NO. 1.4.1.4, MIL-STD-171.
5- REMOVE EMBRITTLEMENT BY HEATING TO 300°F FOR AT LEAST 30 MINUTES AS SOON AFTER PLATING AS IS POSSIBLE.

NEXT ASSY 8864258	USED ON T5E2, T4E1, & T5E1
HAIRSPRING VIBRATING CO UNION CITY, N. J.	
DR A.S.P	SCALE
CH	REVISION / DATE
APPR	
DATE 9/7/62	
TITLE CLICK	NO. 8864255

HV-5



NOTES:

1- SPECIFICATION MIL-A-2550 AND MIL-STD-8 APPLY.

2-MATERIAL:-BRASS, STRIP, 1/2 OR 3/4 HARD, SPEC. ASTM B36.

3-FINISH ALL OVER 63 EXCEPT AS NOTED.

BRITISH GEAR DATA

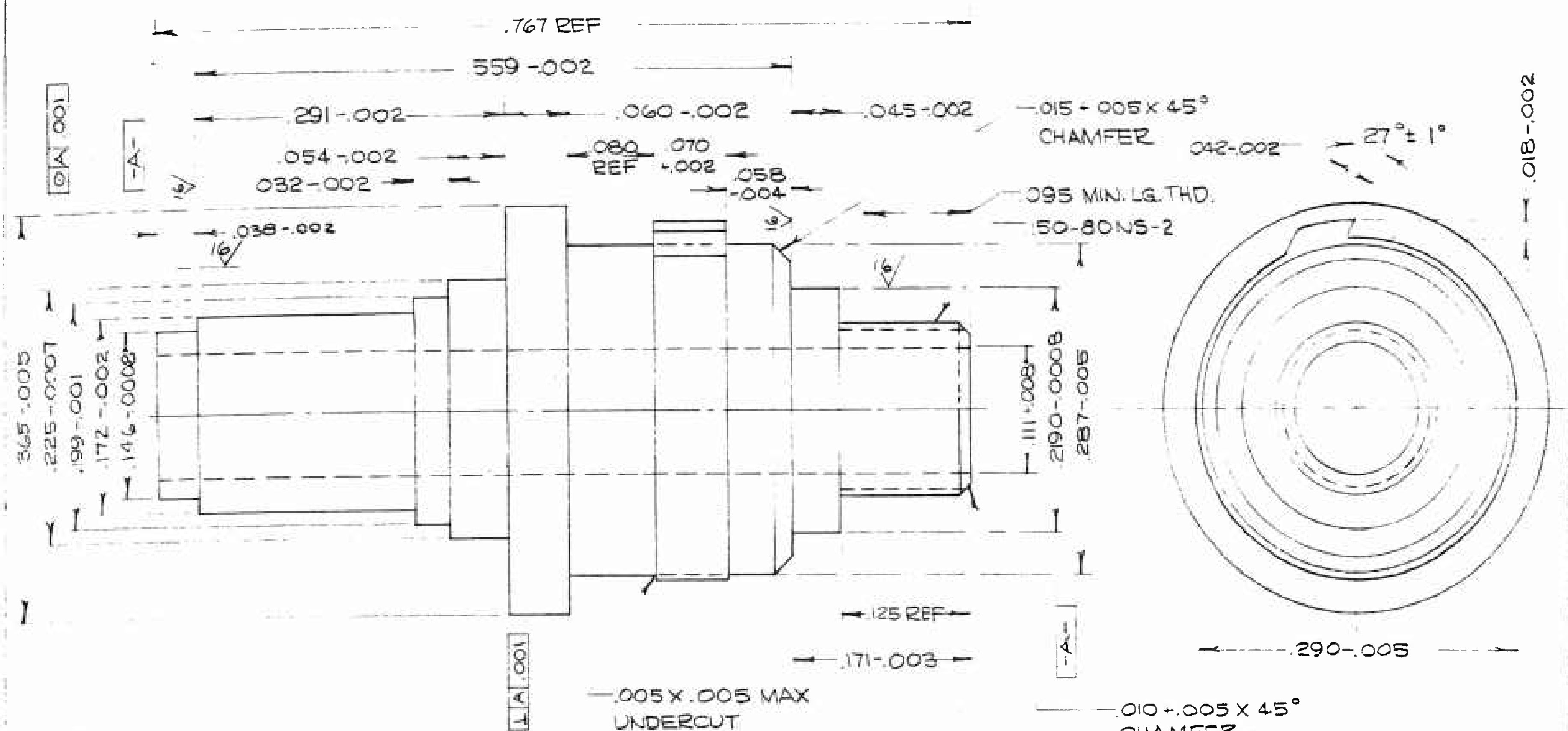
NUMBER OF TEETH 66

MODULE .23

BRITISH STD. 978, PART 2

NEXT ASSY 8864258	USED ON T3E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N.J.	
DR. A.S.P. SCALE 5:1	REVISION DATE
CH.	
APPR.	
DATE 9/7/63	
TITLE GEAR, CENTER	8864256

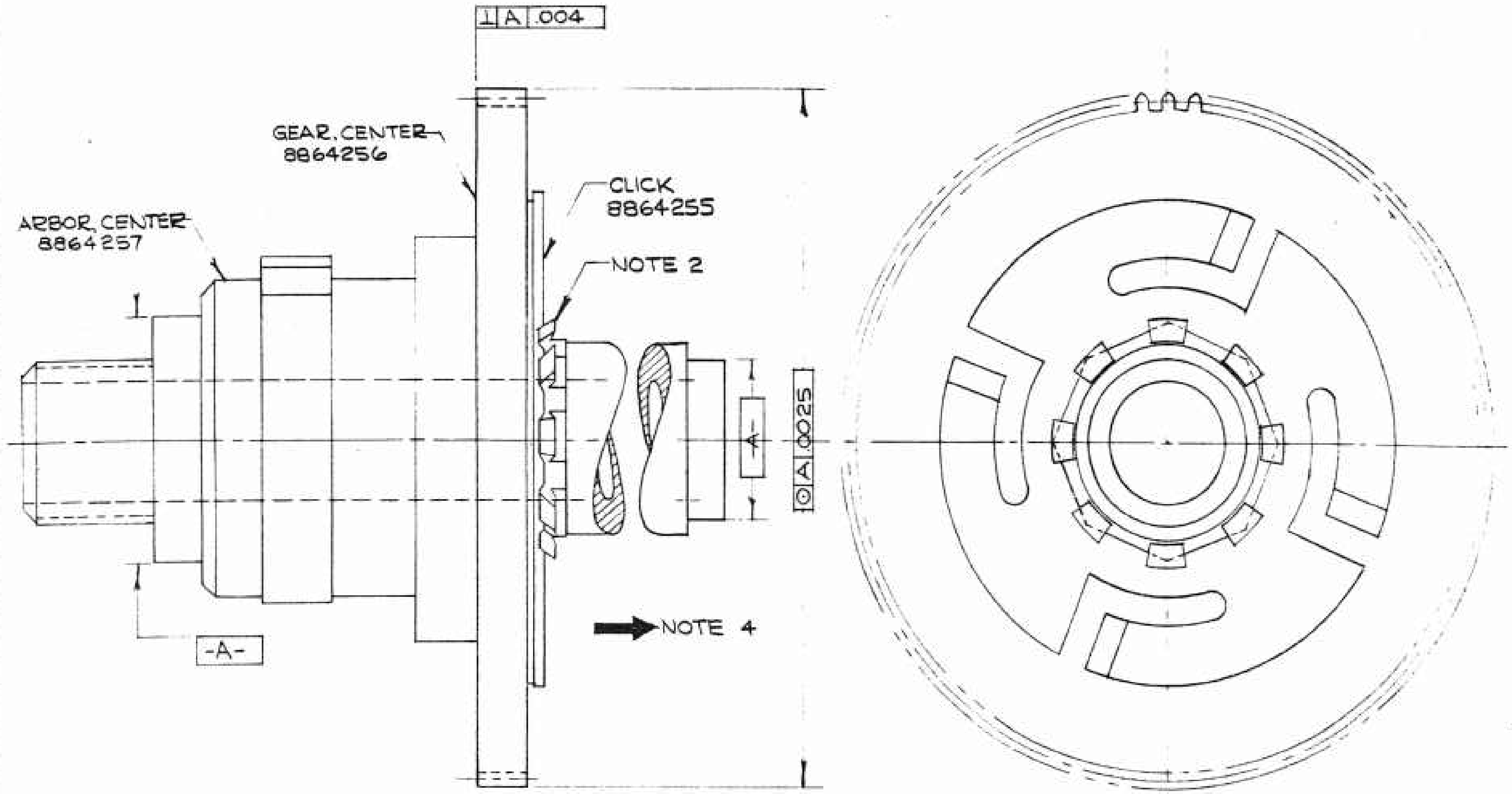
HV-6



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- MAT'L: STEEL, BAR, SPEC. ASTM A108, (NOTE 4)
3- ALTERNATE MAT'L: STAINLESS STEEL, BAR, COLD FINISHED, TYPE 416, SPEC. ASTM A276.
4- PROTECTIVE FINISH: FINISH NO. 1.1.2.2. OR 19.2.2. MIL-STD-171.
5- FINISH ALL OVER 63/ EXCEPT AS NOTED.

NEXT ASSY 8864258		USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO ... TORQUE CONTROLS, INC UNION CITY, N.J.			
DR A.S.P			DATE
CH	A	A.S.P.	3/11/63
APPR	B	T.F.S.	3-25-63
DATE 9/7/62			
TITLE ARBOR, CENTER		NO. 8864257	

HV-7

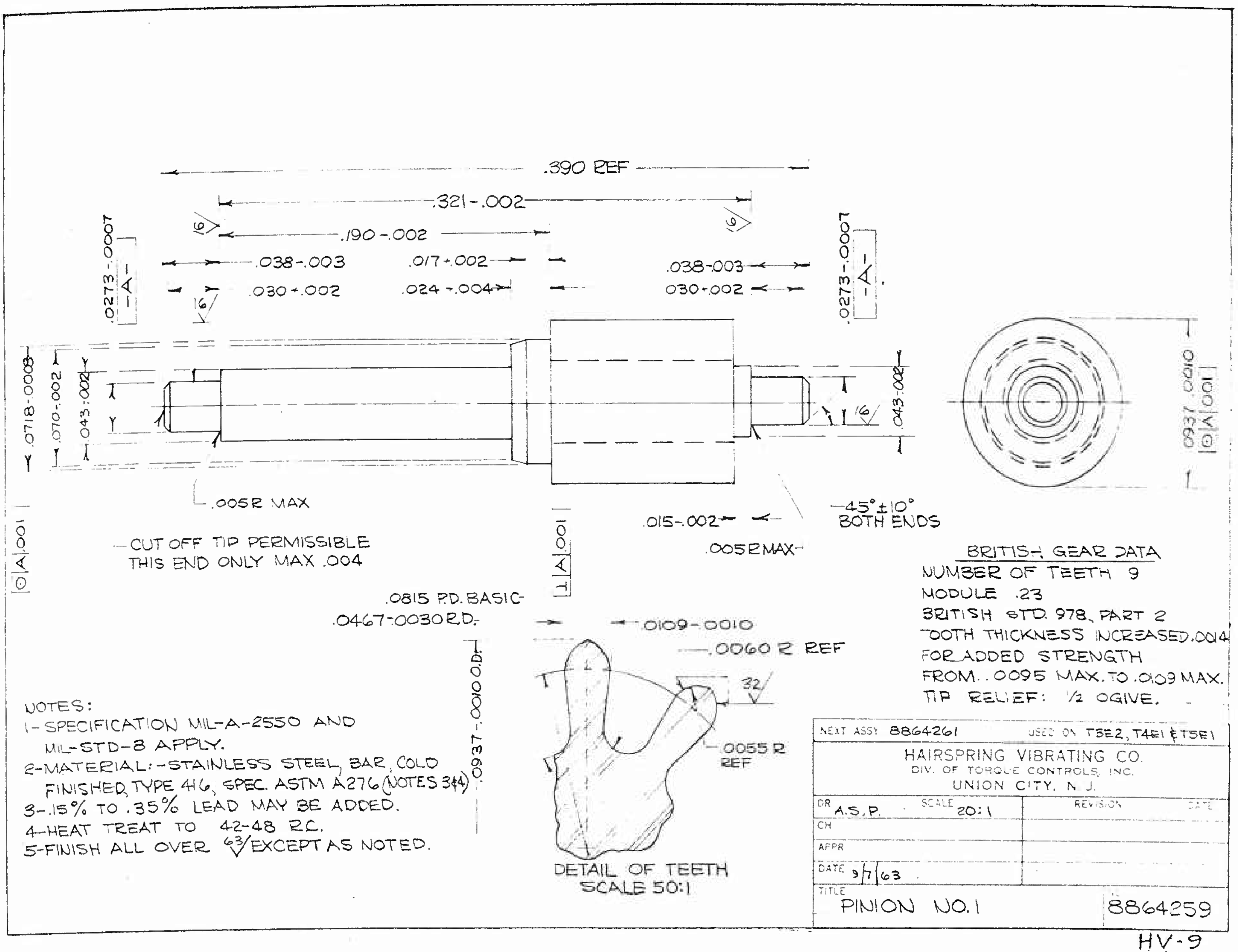


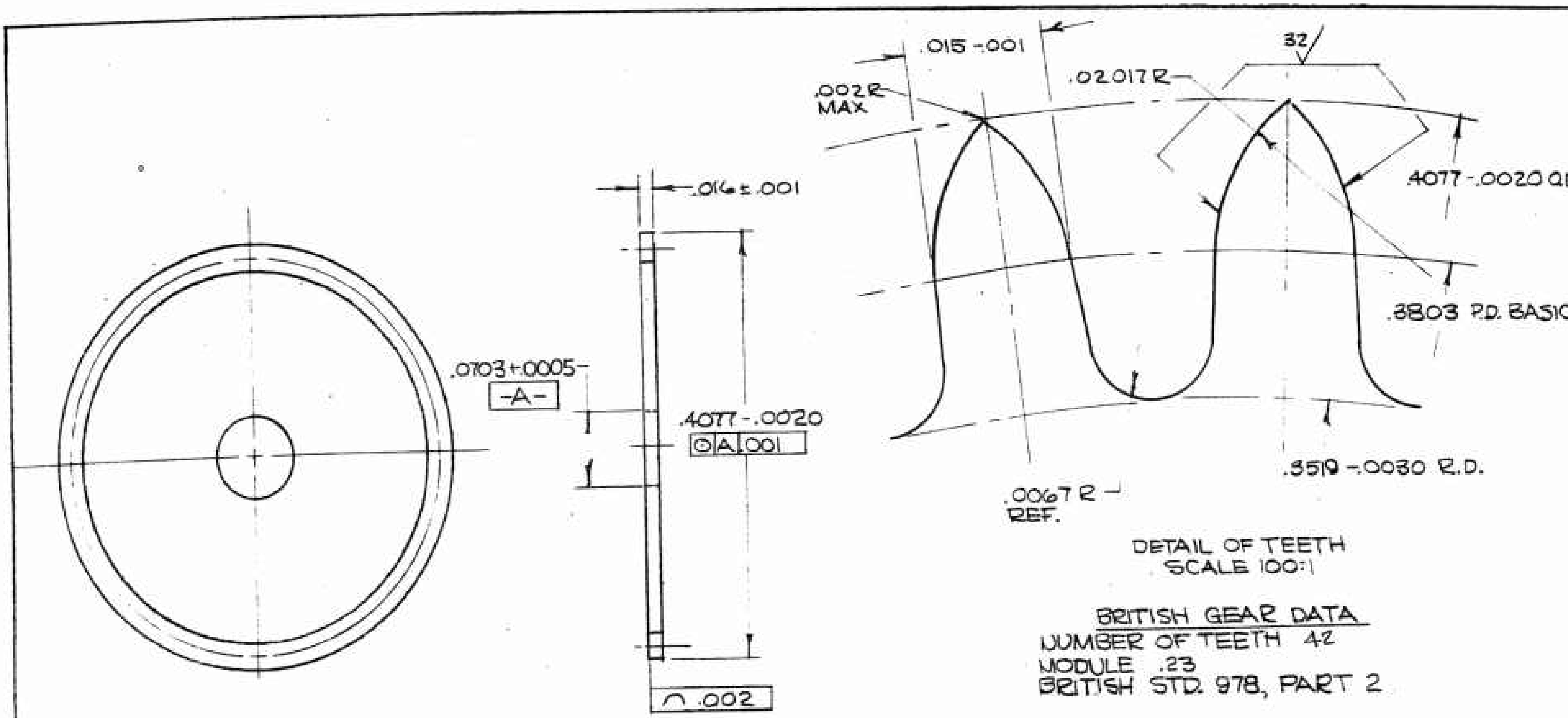
NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- STAKE SECURELY 8 PLACES AS SHOWN. (SEE NOTE. 4)
3- GEAR MUST MOVE FREELY WITHIN GEAR CUTOUTS (4 PLACES).
4- CLICK MUST WITHSTAND A MINIMUM LOAD OF 50 LBS. IN THE DIRECTION SHOWN.

NEXT ASSY 8864282	USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N.J.		
DR A.S.P.	SCALE	
CH	A ASP 1/11/63	
APPR		
DATE 9/7/62		
TITLE ARBOR & CENTER GEAR ASSEMBLY		8864258

HV-8


.390 REF
.321-.002
.190-.002
.038-.003
.030+.002
.017+.002
.024+.004
.038-.003
.030+.002
.0273-.0007
-A-
.0718-.0008
.070-.002
.043-.002
.005R MAX
CUT OFF TIP PERMISSIBLE
THIS END ONLY MAX .004
.015-.002
.005R MAX
45°±10°
BOTH ENDS
.0937-.0010
.0815 P.D. BASIC
.0467-.0030 R.D.
.0937-.0010 O.D.
.0109-.0010
.0060 R REF
.0055 R REF
DETAIL OF TEETH
SCALE 50:1
BRITISH GEAR DATA
NUMBER OF TEETH 9
MODULE .23
BRITISH STD. 978, PART 2
TOOTH THICKNESS INCREASED .0014
FOR ADDED STRENGTH
FROM .0095 MAX. TO .0109 MAX.
TIP RELIEF: 1/2 OGIVE.
NOTES:
1-SPECIFICATION MIL-A-2550 AND
MIL-STD-8 APPLY.
2-MATERIAL:-STAINLESS STEEL, BAR, COLD
FINISHED, TYPE 416, SPEC. ASTM A276 (NOTES 3&4)
3-.15% TO .35% LEAD MAY BE ADDED.
4-HEAT TREAT TO 42-48 R.C.
5-FINISH ALL OVER 63 EXCEPT AS NOTED.
NEXT ASSY 8864261
USED ON T3E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO.
DIV. OF TORQUE CONTROLS, INC.
UNION CITY, N. J.
DR A.S.P.
SCALE 20:1
REVISION
DATE
CH
APPR
DATE 3/7/63
TITLE
PINION NO. 1
8864259
HV-9



NOTES:

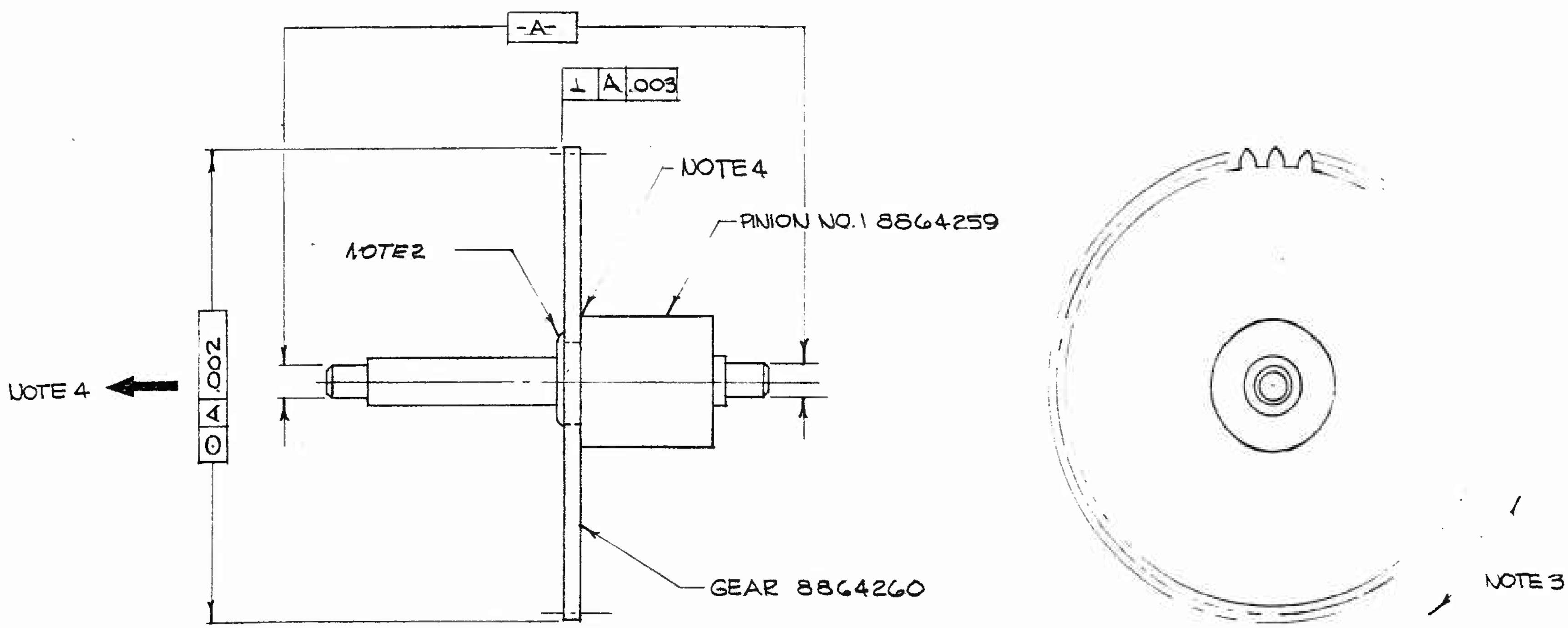
1- SPECIFICATION MIL-A-2550 AND MIL-STD-8 APPLY

2-MATERIAL:- BRASS, STRIP, 1/2 OR 3/4 HARD, SPEC. ASTM B36

3-FINISH ALL OVER 63/ EXCEPT AS NOTED.

NEXT ASSY. 8864261	USED ON: T3E2, T451 & T5E1
NEXT ASSY. 8864265	USED ON. T3E2, T461 & T5E1
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.	
DR. A.S.P. SCALE 10:1	REVISION DATE
CH.	
APPR	
DATE 9/8/63	
TITLE GEAR	NO. 8864260

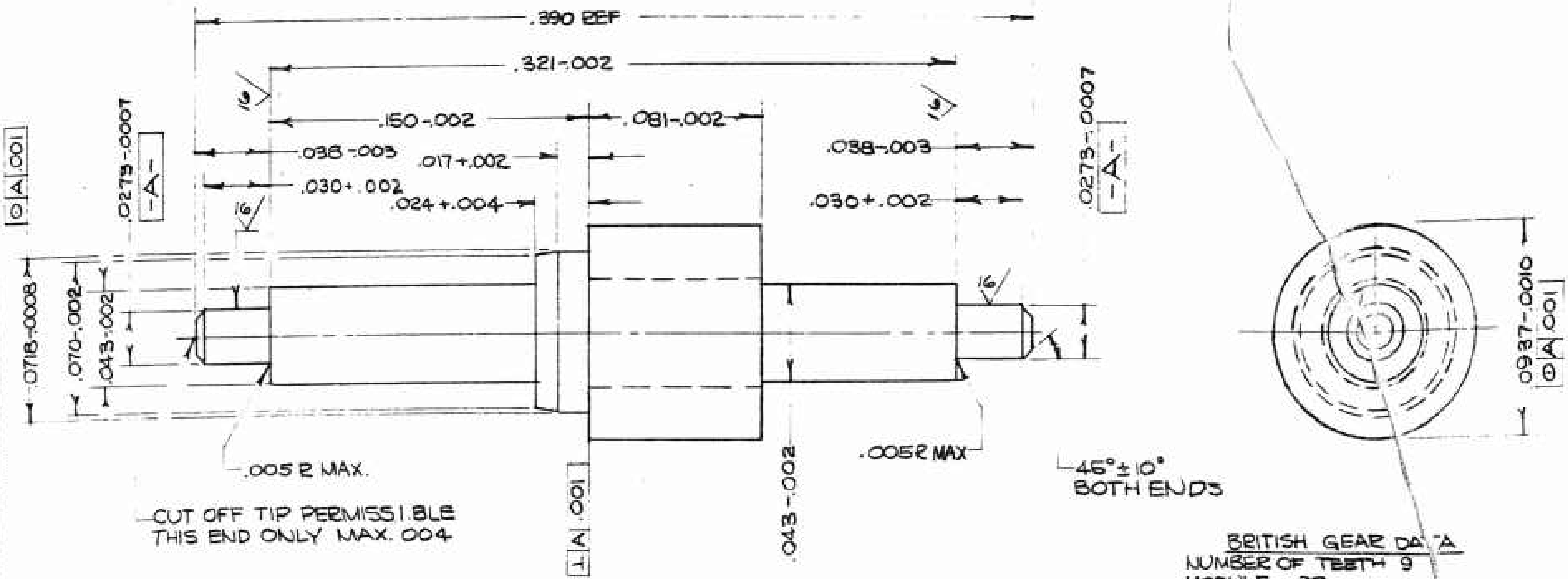
HV-10



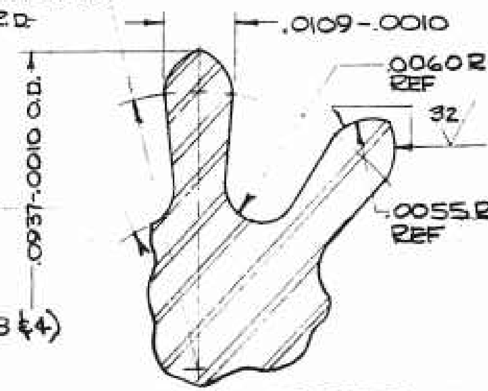
NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- SECURE GEAR TO PINION BY ANY SUITABLE METHOD, (SEE NOTES 3 & 4)
3- GEAR NO. 1 MUST WITHSTAND A MINIMUM TORQUE OF 20 OUNCE-INCHES IN EITHER DIRECTION AS SHOWN.
4- GEAR MUST WITHSTAND A MINIMUM LOAD OF 24 POUNDS APPLIED IN THE DIRECTION SHOWN WITHOUT ANY VISIBLE GAP BETWEEN THE GEAR & THE PINION SHOULDER.

NEXT ASSY 8864282	USED ON T3E2, T4E1 & T5E1		
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR A.S.P.	SCALE 10:1	REVISION	DATE
CH		Δ A.S.P.	3/11/63
APPR.			
DATE 9/8/62			
TITLE PINION NO. 1 AND GEAR ASSEMBLY		8864261	

HV-11



BRITISH GEAR DATA
NUMBER OF TEETH 9
MODULE .23
BRITISH STD. 978, PART 2
TOOTH THICKNESS INCREASED
.0014 FOR ADDED STRENGTH
FROM .0095 MAX. TO .0109 MAX.
TIP RELIEF: 1/2 OGIVE.

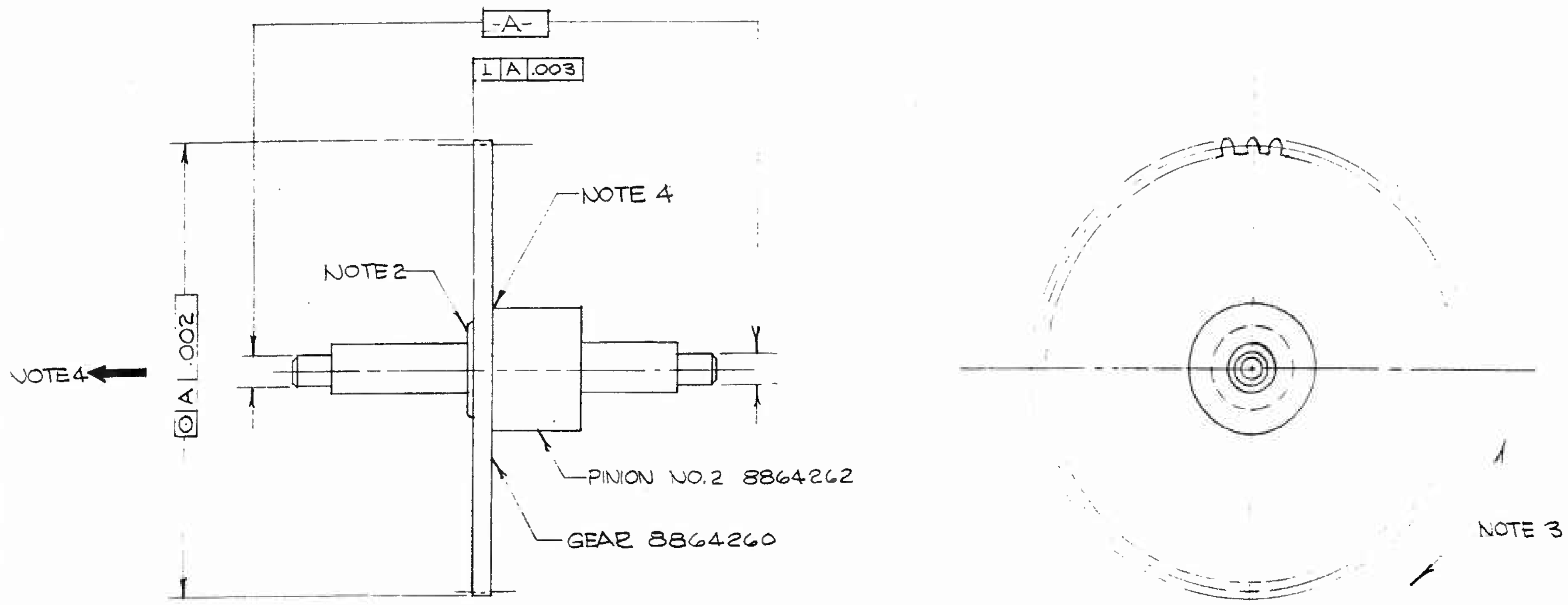


DETAIL OF TEETH
SCALE 50:1

NOTES:
1- SPECIFICATION MIL-A-2550 AND
MIL-STD-6 APPLY
2- MATERIAL:-STAINLESS STEEL, BAR, COLD FINISHED, TYPE 416, SPEC. ASTM A276 (SEE NOTES 3 & 4)
3- .15% TO .35% LEAD MAY BE ADDED.
4- HEAT TREAT TO 42-48 RC.
5- FINISH ALL OVER 63/ EXCEPT AS NOTED.

NEXT ASSY. 8864263	USED ON T3B2, T4E1 & T5E1		
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A.S.P.	SCALE 20:1	REVISION	DATE
CH		A A.S.P.	8/11/63
APPR		B T.F.J.	3-25-63
DATE 9/8/62			
TITLE PINION NO. 2		NO. 8864262	

HV-13

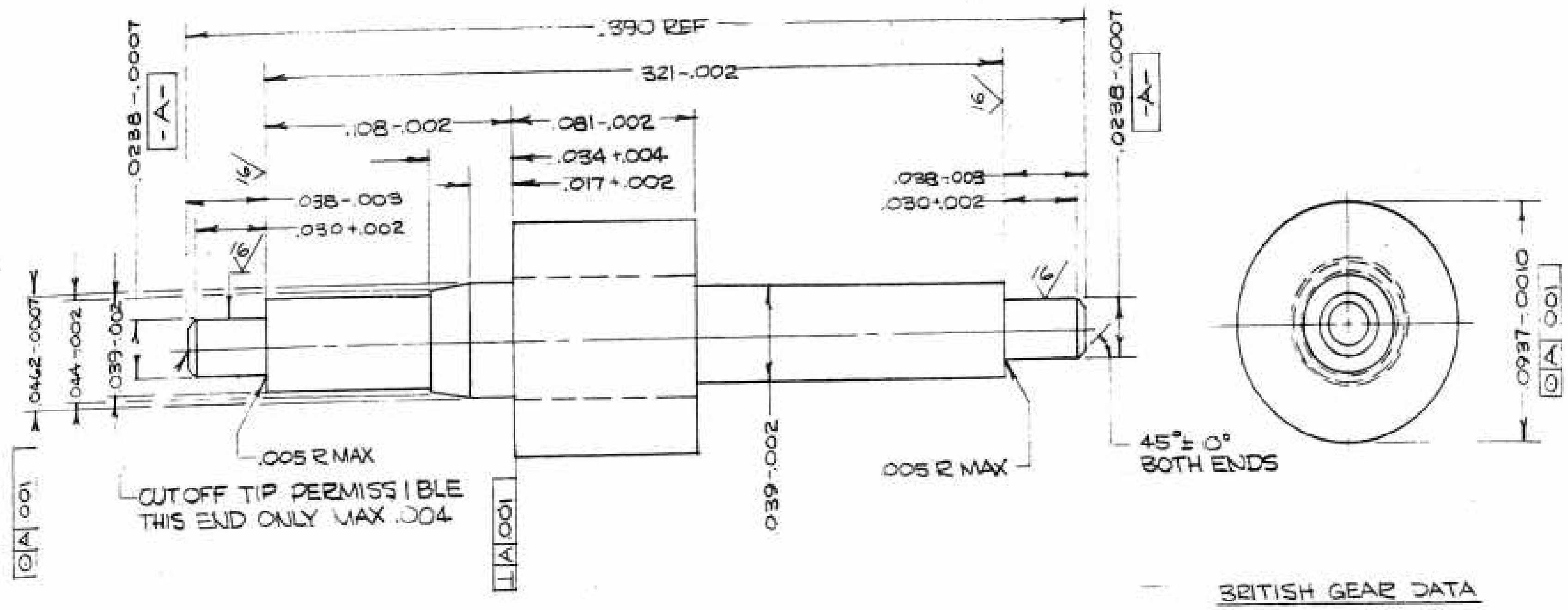


NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2- SECURE GEAR TO PINION BY ANY SUITABLE METHOD (SEE NOTES 3 & 4).
3- GEAR NO. 2 MUST WITHSTAND A MINIMUM TORQUE OF 20 OUNCE-INCHES IN EITHER DIRECTION AS SHOWN.
4- GEAR MUST WITHSTAND A MINIMUM LOAD OF 24 POUNDS APPLIED IN THE DIRECTION SHOWN WITHOUT ANY VISIBLE GAP BETWEEN THE GEAR & THE PINION SHOULDER.

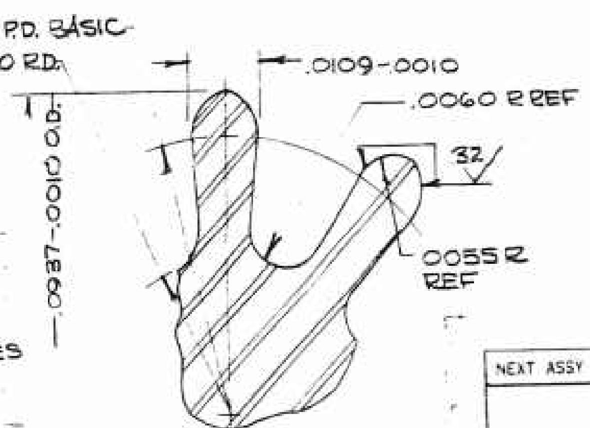
NEXT ASSY 8864282		USED ON T5E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A.S.P.	SCALE 10:1	REVISION	DATE
CH.			
APPR.			
DATE 9/8/63			
TITLE PINION NO. 2 AND GEAR ASSEMBLY		NO. 8864263	

HV-14



BRITISH GEAR DATA

NUMBER OF TEETH 9
MODULE .23
BRITISH STD. 978, PART 2
TOOTH THICKNESS INCREASED .0014 FOR ADDED STRENGTH FROM .0095 MAX. TO .0109 MAX.
TIP RELIEF: 1/2 OGIVE.

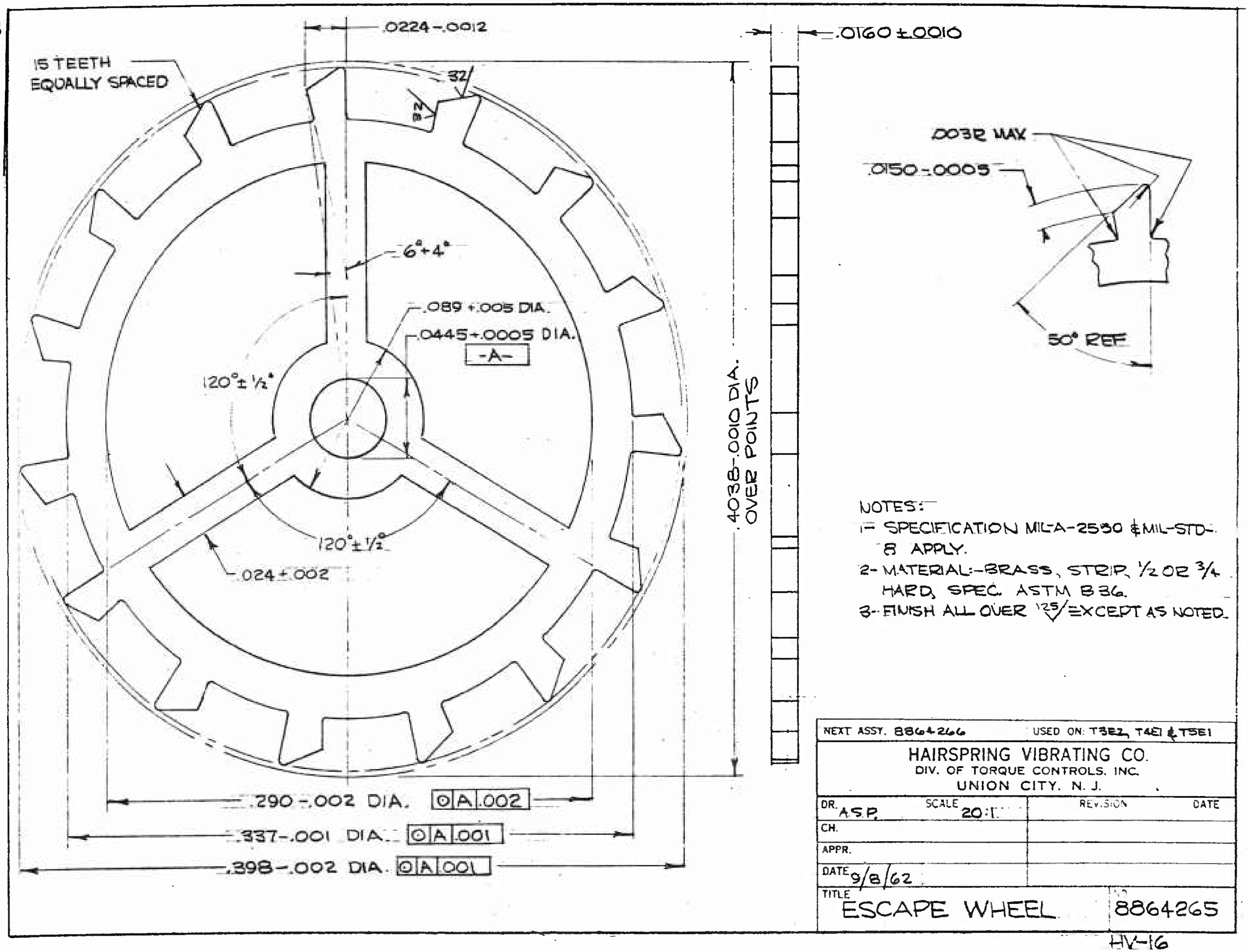


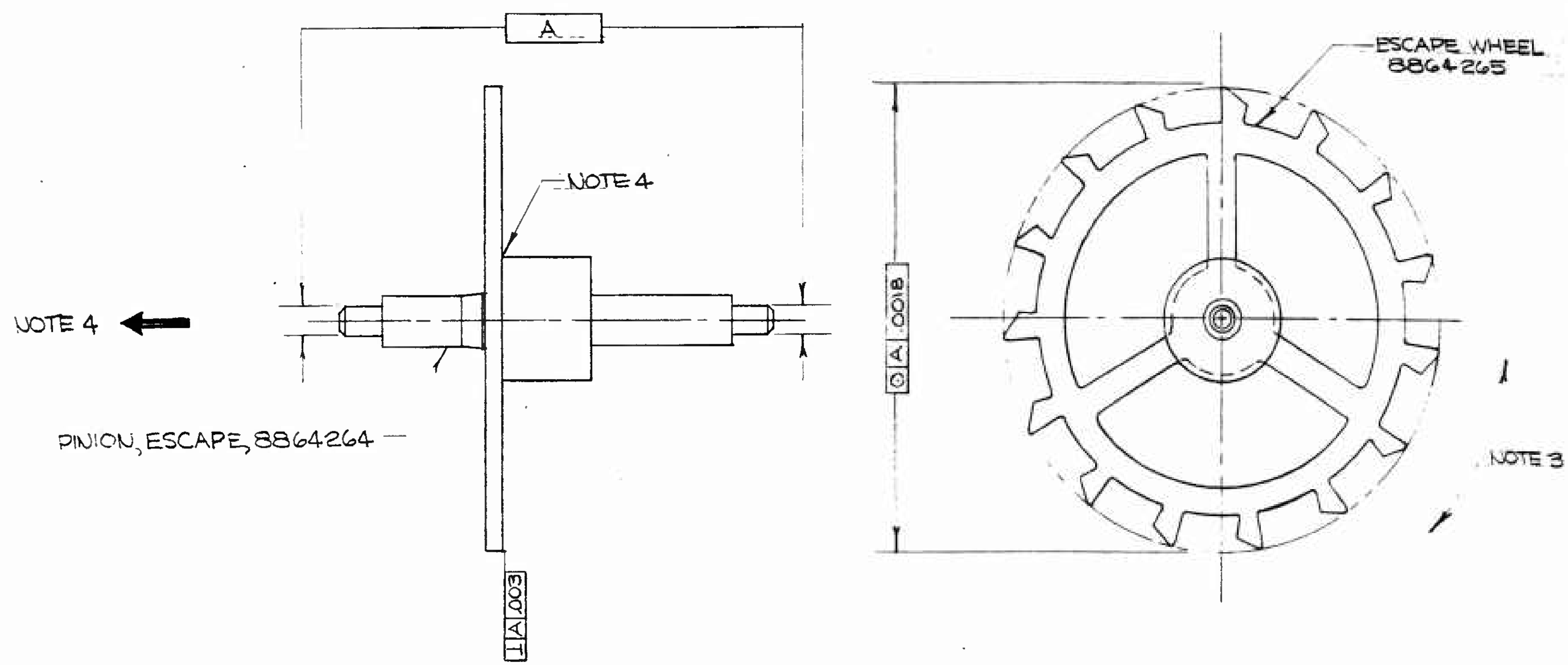
DETAIL OF TEETH
SCALE 50:1

NOTES:
1- SPECIFICATION MIL-A-2550 AND MIL-STD-8 APPLY.
2- MATERIAL:- STAINLESS STEEL, BAR, COLD FINISHED, TYPE 416, SPEC. ASTM A276 (SEE NOTES 3 & 4)
3- .15% TO .35% LEAD MAY BE ADDED.
4- HEAT TREAT TO 42-48 RC.
5- FINISH ALL OVER 63 EXCEPT AS NOTED.

NEXT ASSY 8864266		USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR A.S.P.	SCALE 20:1	REVISION	DATE
CH		A A.S.P.	3/11/63
APPR			
DATE 9/8/62			
TITLE PINION, ESCAPE		NO 8864264	

HV-15

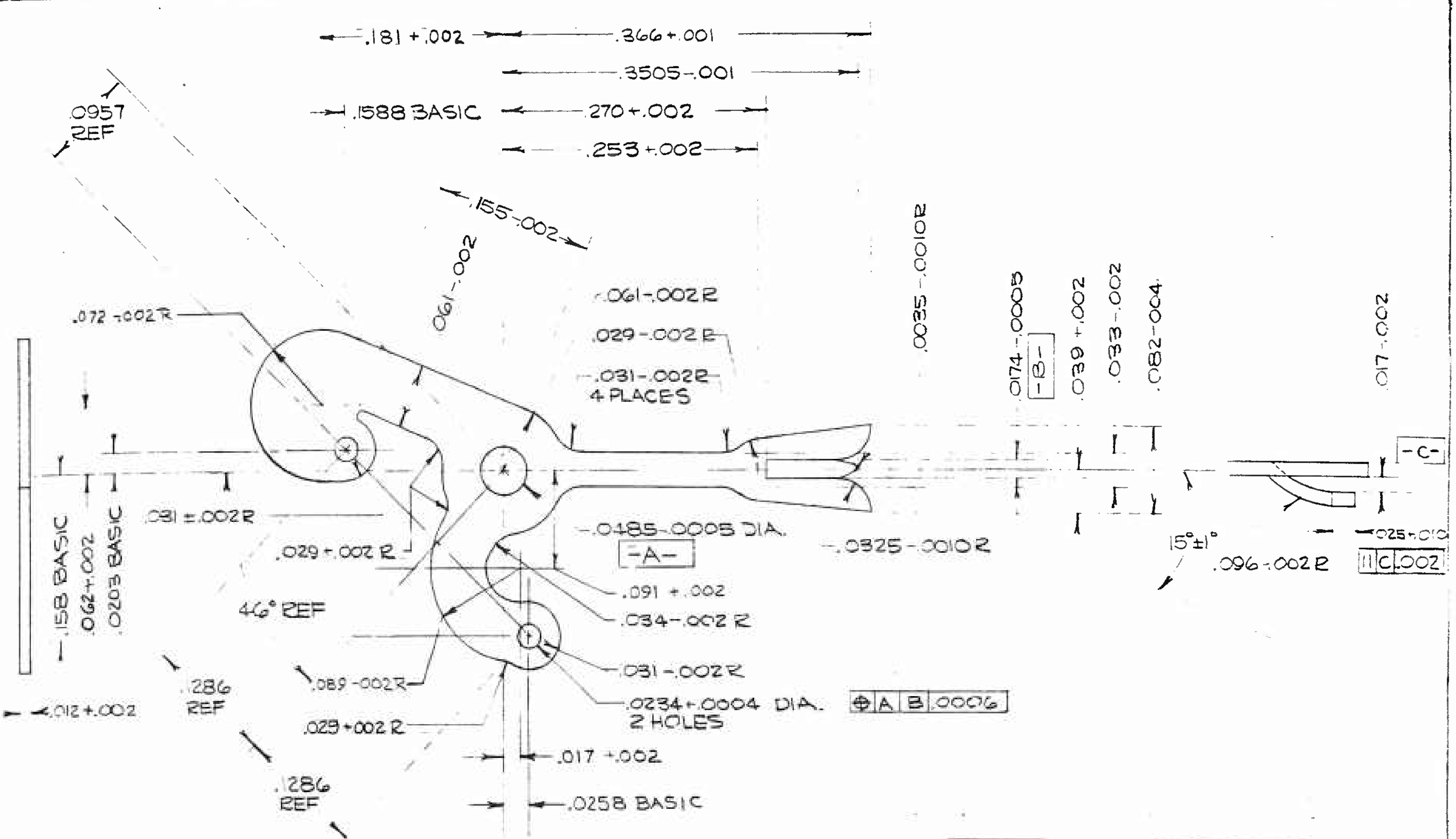

.0224-.0012
15 TEETH EQUALLY SPACED
32
28
.0160 ±.0010
.0032 MAX
.0150-.0005
50° REF
6°+4°
.089 +.005 DIA.
.0445+.0005 DIA.
-A-
120° ± 1/2°
120° ± 1/2°
.024 ± .002
.4038-.0010 DIA. OVER POINTS
.290-.002 DIA. ⊙ A .002
.337-.001 DIA. ⊙ A .001
.398-.002 DIA. ⊙ A .001
NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- MATERIAL:-BRASS, STRIP, 1/2 OR 3/4 HARD, SPEC. ASTM B36.
3- FINISH ALL OVER 125/ EXCEPT AS NOTED.
NEXT ASSY. 8864266
USED ON: T3E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO.
DIV. OF TORQUE CONTROLS, INC.
UNION CITY, N. J.
DR. A.S.P.
SCALE 20:1
REVISION
DATE
CH.
APPR.
DATE 9/8/62
TITLE ESCAPE WHEEL
8864265
HV-16



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- SECURE ESCAPE WHEEL TO THE PINION BY ANY SUITABLE METHOD, (SEE NOTES 3 & 4)
3- ESCAPE WHEEL MUST WITHSTAND A MINIMUM TORQUE OF 3 OUNCE-INCHES IN EITHER DIRECTION AS SHOWN.
4- ESCAPE WHEEL MUST WITHSTAND A MINIMUM LOAD OF 10 LBS. APPLIED IN THE DIRECTION SHOWN WITHOUT ANY VISIBLE GAP BETWEEN THE ESCAPE WHEEL & PINION SHOULDER.

NEXT ASSY 8864282		USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR A. S. P.	SCALE 10:1	REVISION	DATE
CH		A A.S.P.	3/11/63
APPR			
DATE 9/8/62			
TITLE ESCAPE WHEEL & PINION ASSEMBLY		NO. 8864266	

HV17



NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY

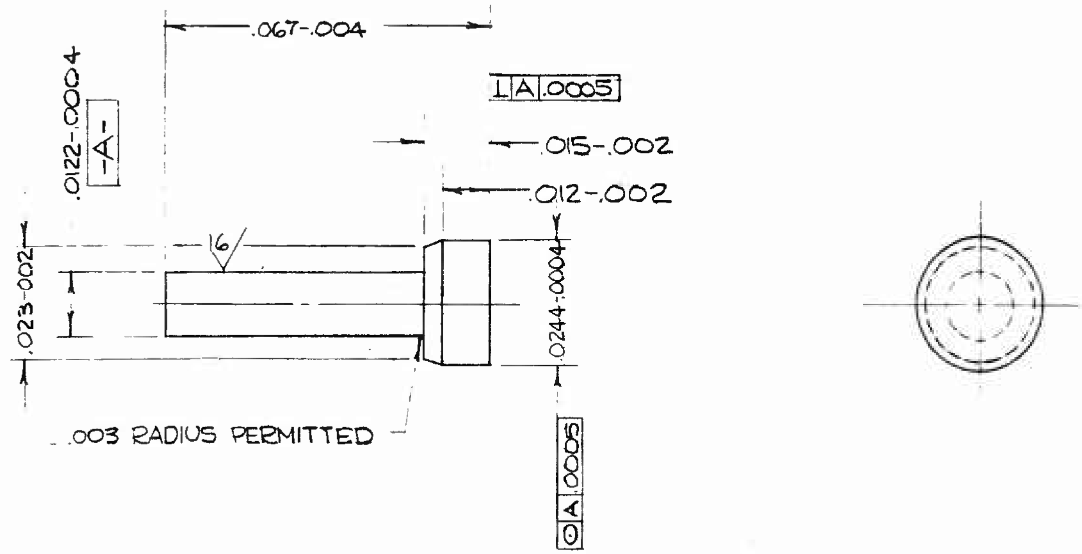
2-MATERIAL:- BRASS, STRIP, 1/2 OR 3/4 HARD, SPEC. ASTM B36.

3-ALL RADII TO BLEND

4-FINISH ALL OVER 125/

NEXT ASSY 8864271	USED ON T3E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC UNION CITY, N. J.	
DR. A. S. P. SCALE 10:1	REVISION DATE
CH	
APPR	
DATE 9/8/62	
TITLE LEVER, PALLET, & GUARD	8864267

HV-18



NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY

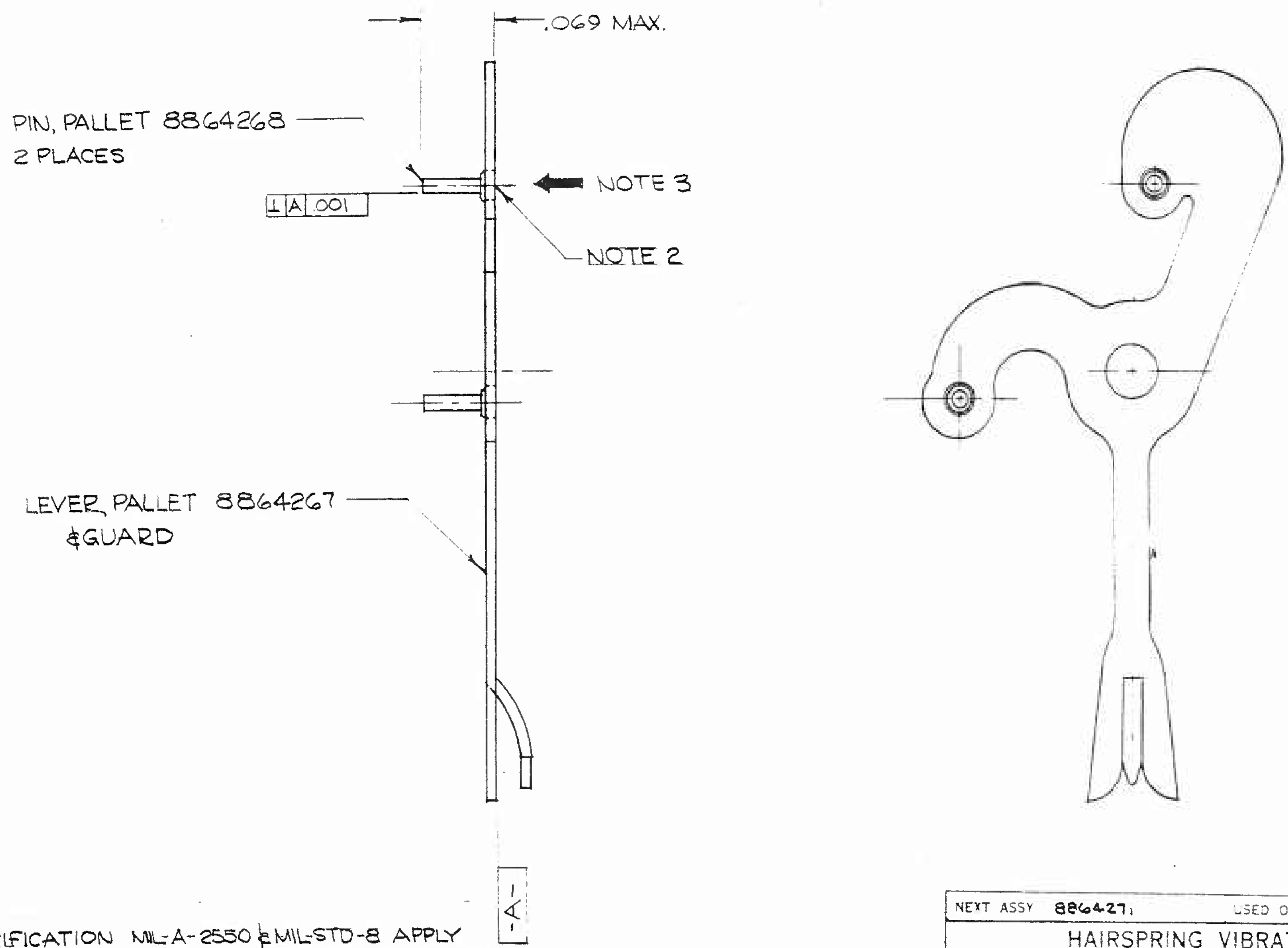
2-MATERIAL: STAINLESS STEEL, BAR, TYPE 440 C, SPEC. ASTM A276

3-HEAT TREAT TO 50-56 RC.

4-FINISH ALL OVER 63 EXCEPT AS SHOWN.

NEXT ASSY. 8864269	USED ON T3E2, T4E1 & T5E1		
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC. UNION CITY, N J			
DR A.S.P.	SCALE 40:1	REVISION	DATE
CH			
APPR			
DATE 9/10/62			
TITLE PIN, PALLET		NO. 8864268	

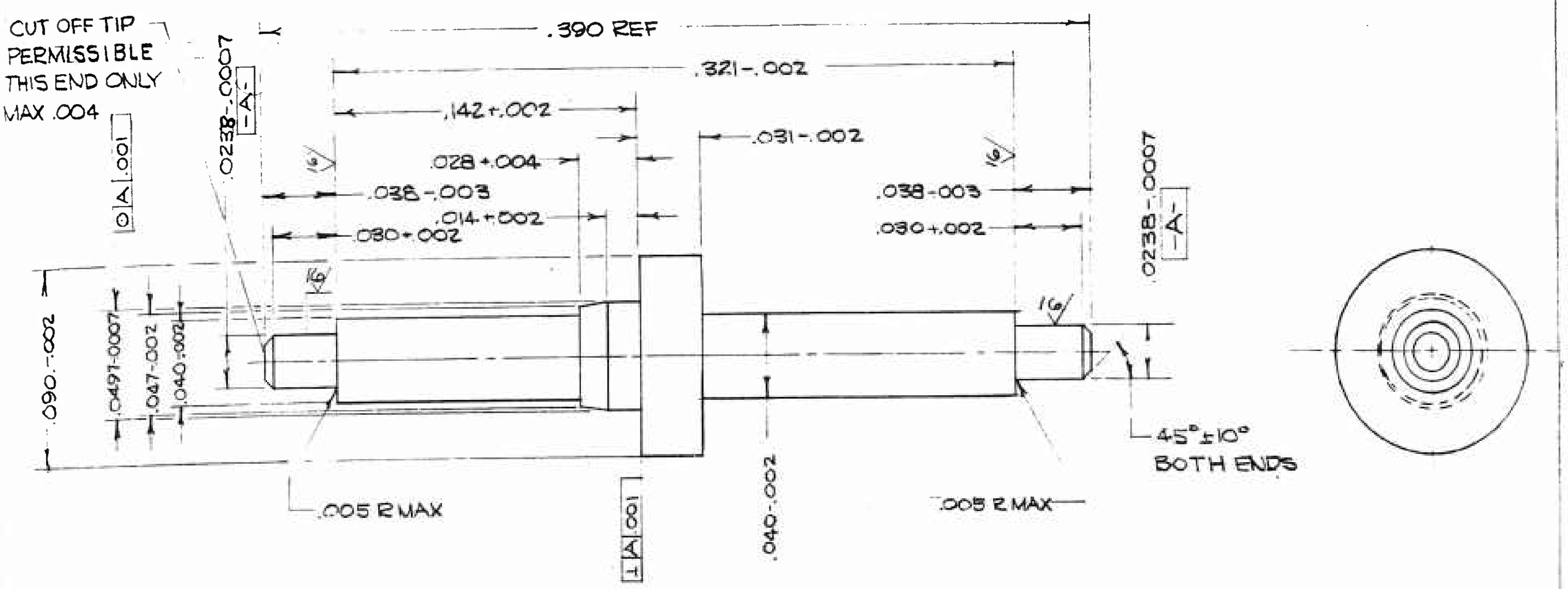
HV-19



NOTES:
1 - SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2 - MUST BE FLUSH TO .002 BELOW FLUSH
3 - PALLET PIN MUST WITHSTAND A MINIMUM LOAD OF 5 LBS. IN DIRECTION SHOWN

NEXT ASSY 8864271		USED ON T3E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N J		
DR A.S.P.	SCALE 10:1	REVISION DATE
CH		
APPR		
DATE 9/10/62		
TITLE PALLET & PIN ASSEMBLY		8864269

HV-20



NOTES.

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY

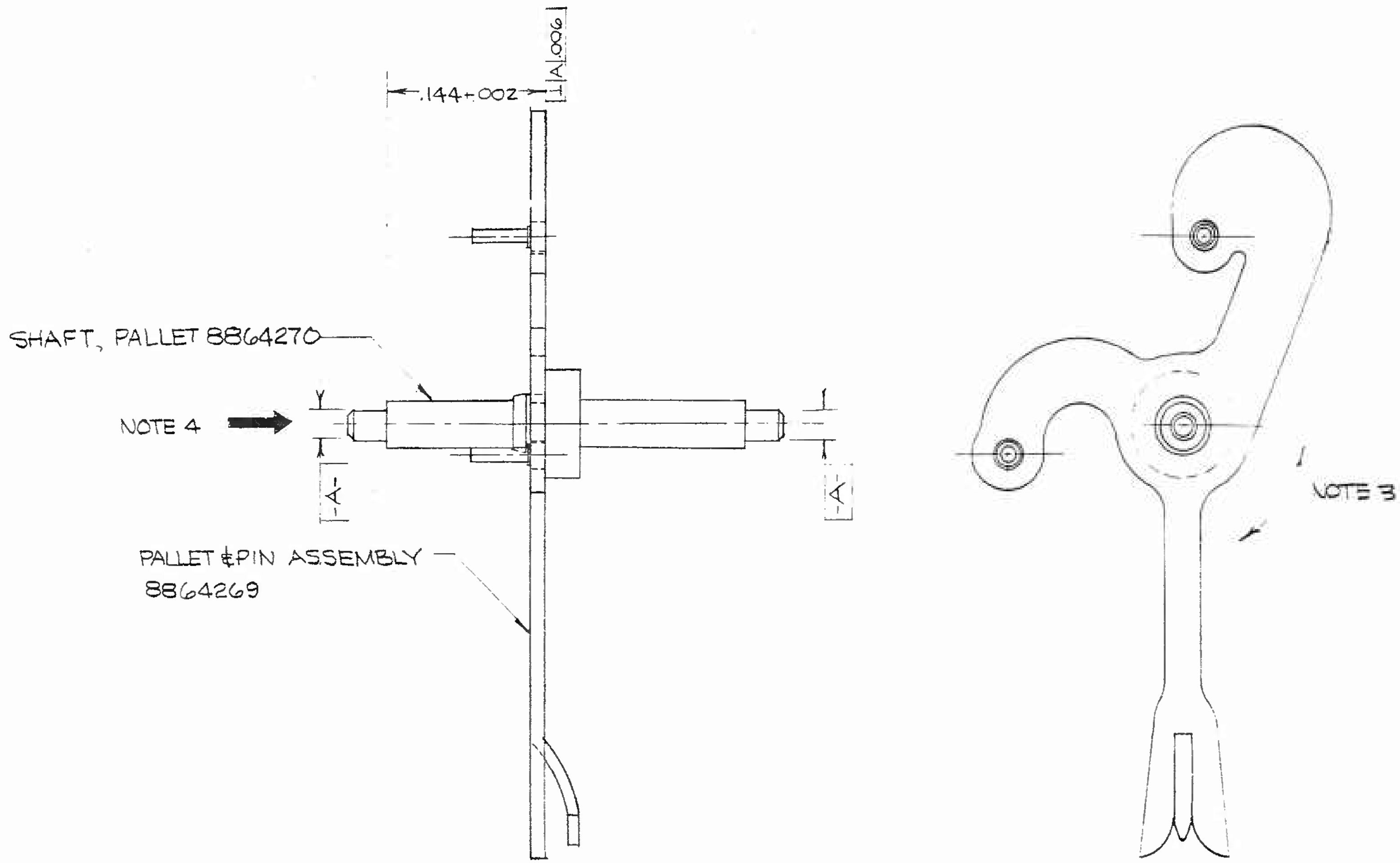
2- MAT'L: STAINLESS STEEL, BAR, COLD FINISHED, TYPE 416, SPEC. ASTM A276.

3- HEAT TREAT TO 42-48 R.C.

4- FINISH ALL OVER 63 EXCEPT AS NOTED.

NEXT ASSY 8864271		USED ON T3E2, T4E1, & T5E1	
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC UNION CITY, N J			
DR. A. S. P.	SCALE 20:1	REVISION	DATE
CH		A A.S.P	3/11/63
APPR.		B T.F.S	3-25-63
DATE 9/10/62			
TITLE SHAFT, PALLET		NO 8864270	

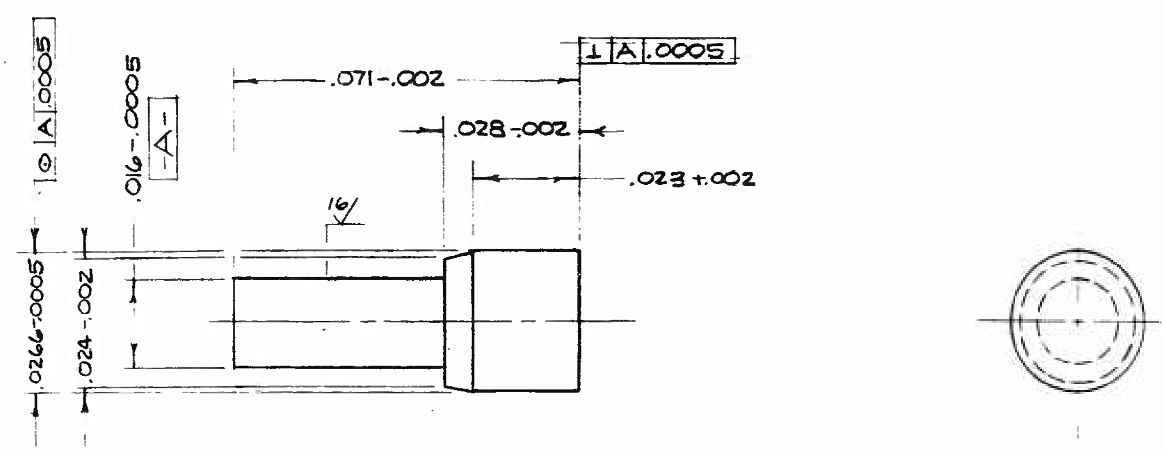
HV-23



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- SECURE SHAFT TO PALLET BY ANY SUITABLE METHOD, (SEE NOTES 3 & 4)
3- PALLET MUST WITHSTAND A MINIMUM TORQUE OF 3 OUNCE INCHES IN EITHER DIRECTION AS SHOWN.
4- PALLET, PIN, & GUARD ASSEMBY MUST WITHSTAND A MINIMUM LOAD OF 10 POUNDS APPLIED IN THE DIRECTION SHOWN WITHOUT ANY VISIBLE GAP BETWEEN THE PALLET AND PALLET SHAFT SHOULDER.

NEXT ASSY 8864282		USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO			
DR A.S.P.	10:1		
CH		A. A.S.P.	3/11/63
APPR			
DATE 9/10/62			
TITLE PALLET LEVER ASSEMBLY 8864271			

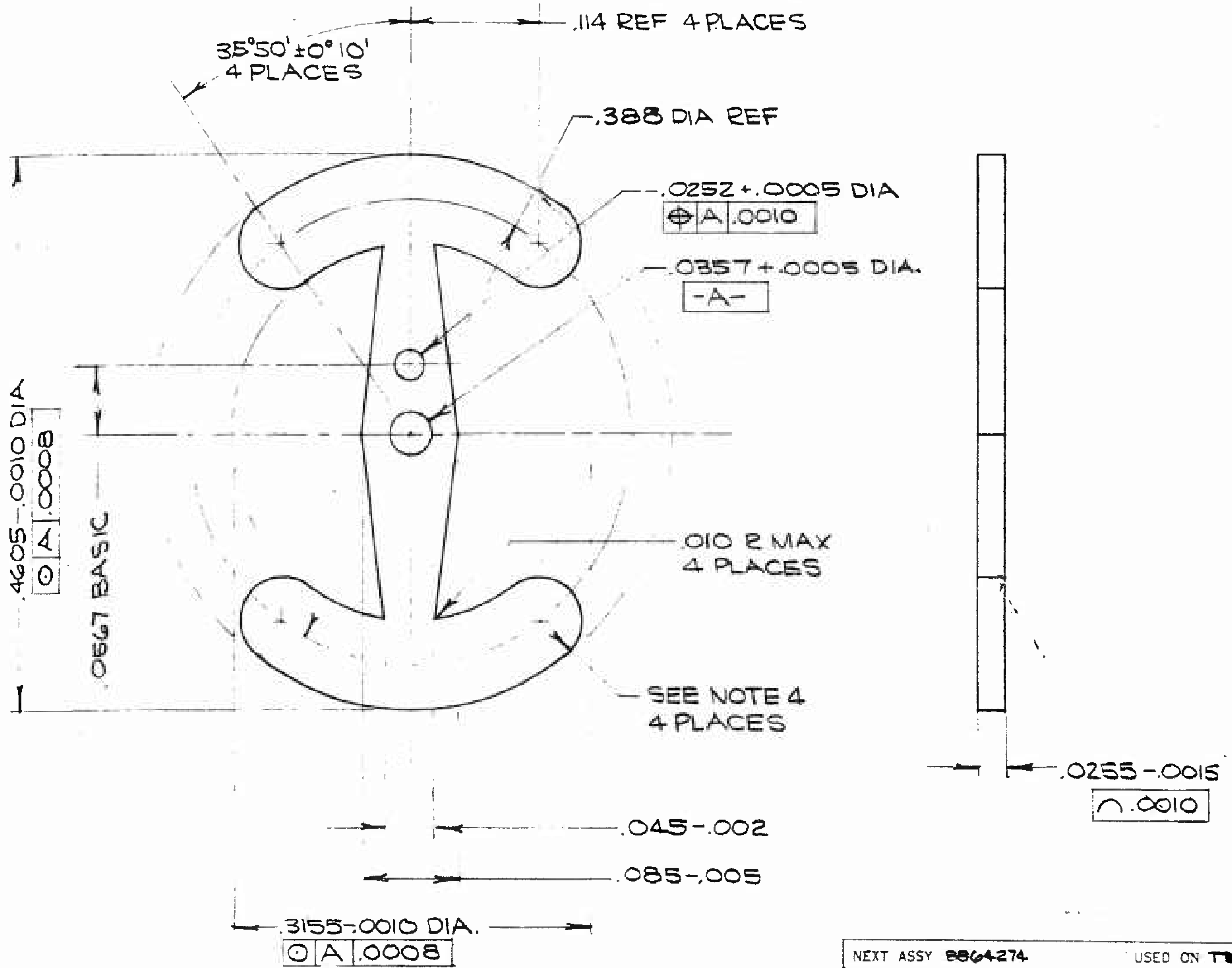
HV-24



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2- MAT'L: STAINLESS STEEL, BAR, TYPE 440C, SPEC. ASTM A276
3- HEAT TREAT TO 50-56 RC.
4- FINISH ALL OVER 63/ EXCEPT AS NOTED.

NEXT ASSY. 8864274		USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A.S.P.	SCALE 40:1	REVISION	DATE
CH.		A T.F.S.	3-25-63
APPR.			
DATE 9/10/62			
TITLE PIN, IMPULSE		NO. 8864272	

HV-25



NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY

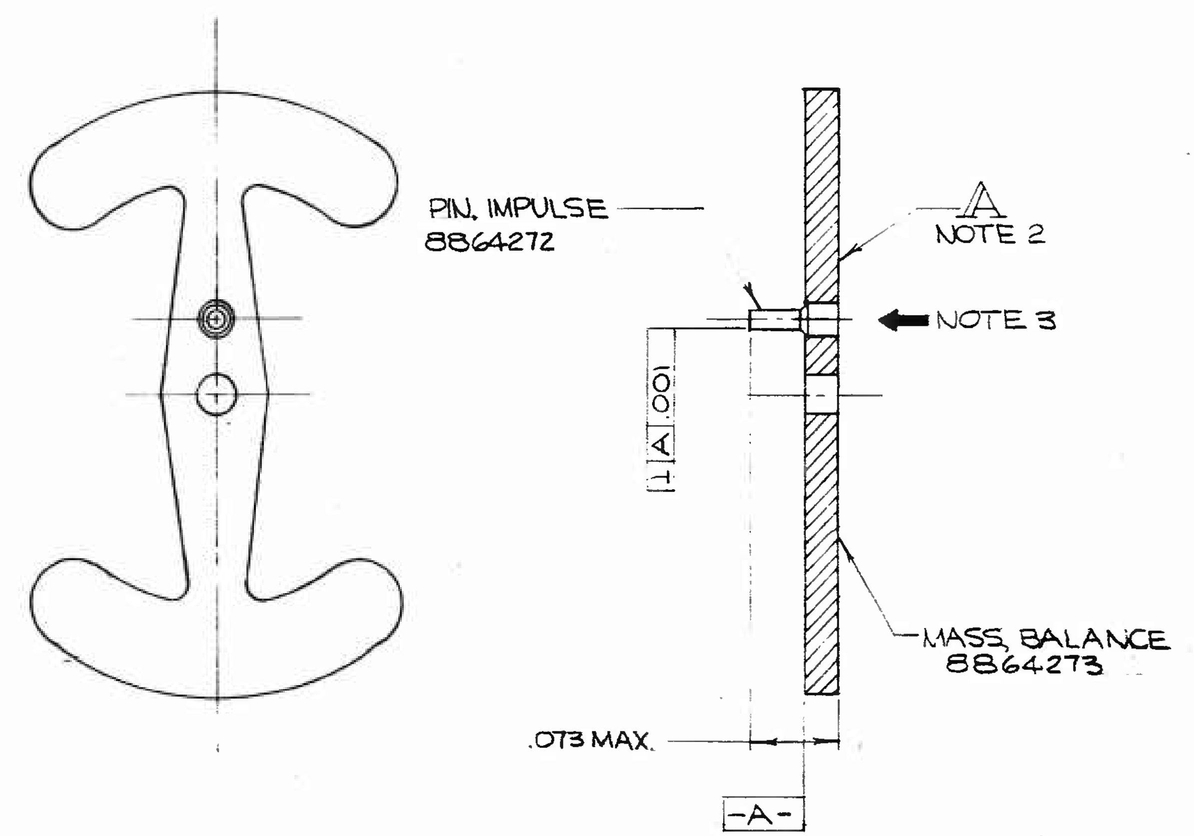
2- MATERIAL:- BRASS, STRIP, 1/2 OR 3/4 HARD, ALLOY #5, SPEC ASTM B121.

3- FINISH ALL OVER 125/

4 RADIUS EQUAL ONE-HALF WIDTH, MUST BLEND.

NEXT ASSY 8864274		USED ON T8E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR A.S.R	SCALE 5:1	REVISION	DATE
CH		4. A.S.R.	9/11/63
APPR			
DATE 9/10/62			
TITLE MASS, BALANCE		NO. 8864273	

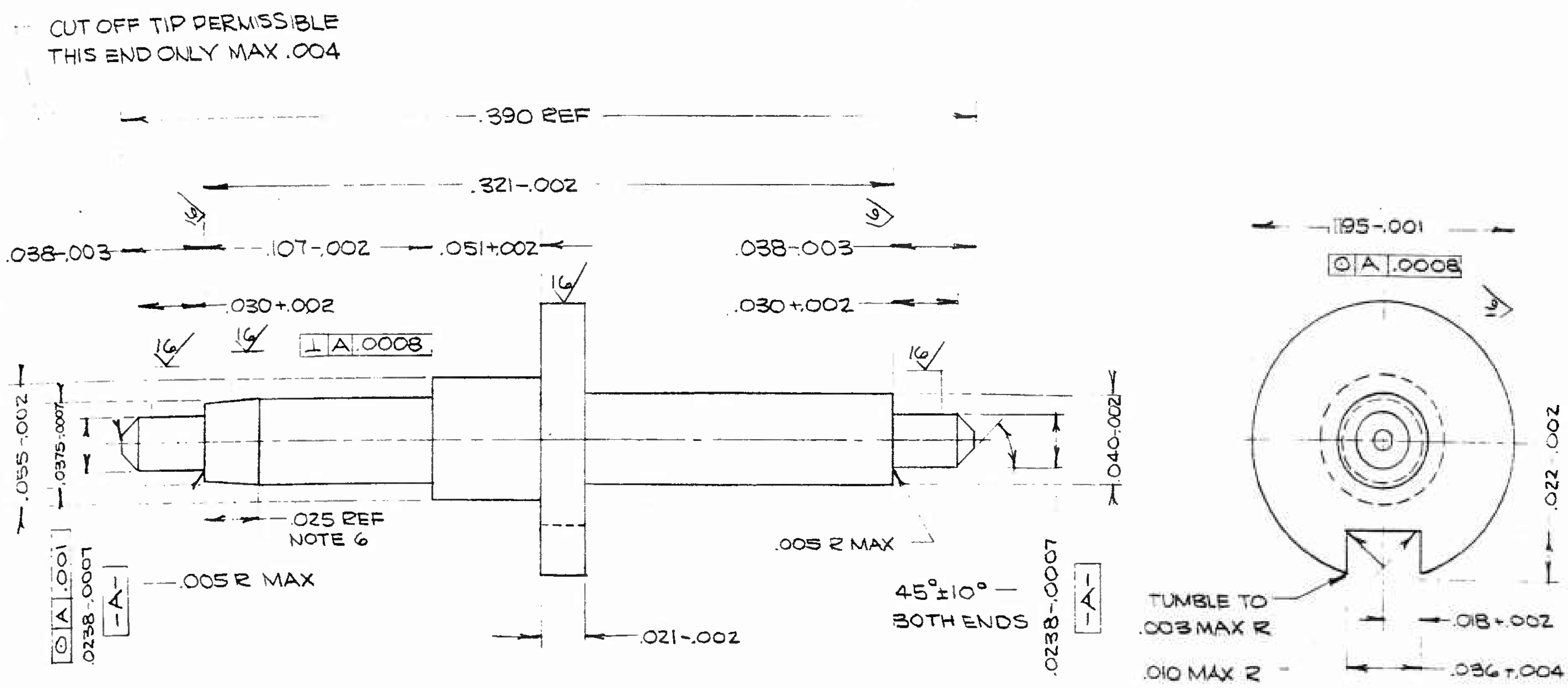
HV-26



NOTES:
1- SPECIFICATON MIL-A-2550 & MIL-STD-8 APPLY.
2- IMPULSE PIN MUST BE FLUSH TO .002 BELOW SURFACE A.
3- IMPULSE PIN MUST WITHSTAND A MINIMUM LOAD OF 5LBS. IN DIRECTION SHOWN.

NEXT ASSY 8864-276		USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A.S.P.	SCALE 10:1	REVISION	DATE
CH			
APPR			
DATE			
TITLE BALANCE & IMPULSE PIN ASSEMBLY		NO. 8864274	

HV-27

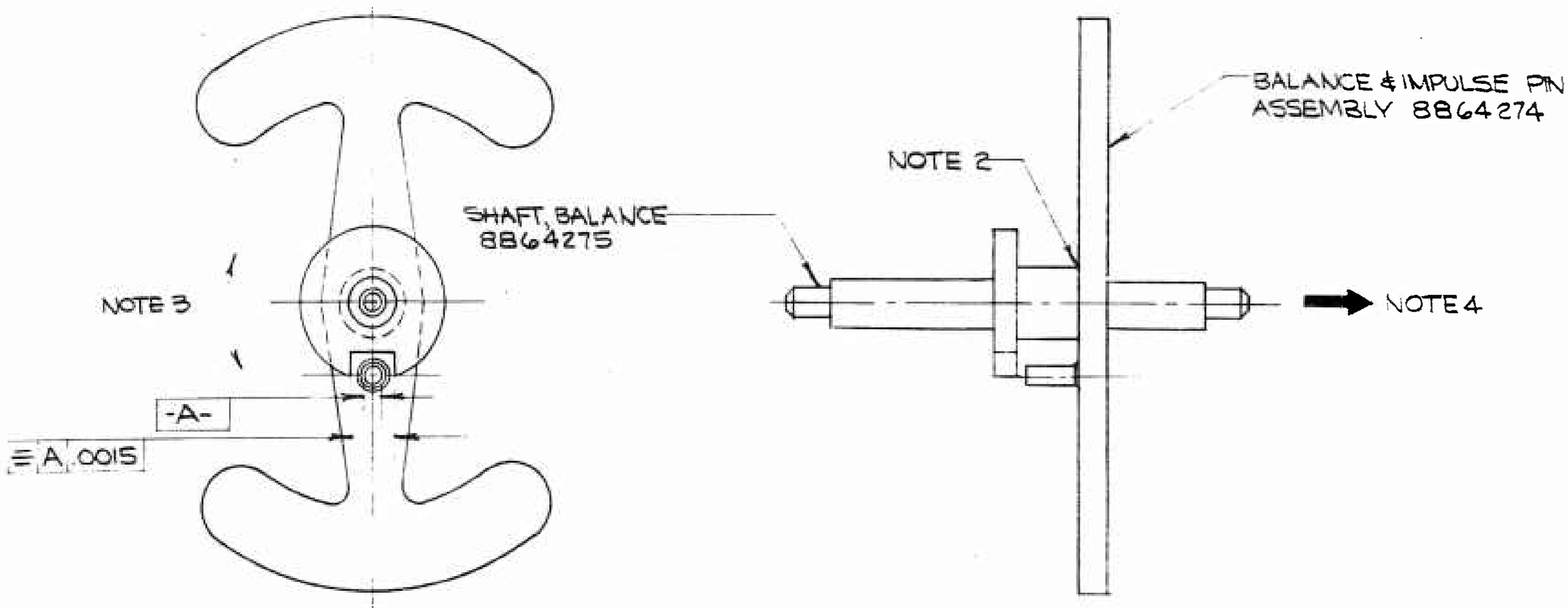


NOTES

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- MAT'L: STAINLESS STEEL, BAR, COLD FINISHED, TYPE 416, SPEC. ASTM A276 (SEE NOTES 3 & 4)
3- .15% TO .35% LEAD MAY BE ADDED.
4- HEAT TREAT TO 42-48 RC.
5- FINISH ALL OVER 63/ EXCEPT AS NOTED.
6- ADVISORY: 2° TAPER FACILITATES MEETING TORQUE REQUIREMENTS OF DWGS. HV-29 & HV-33.

NEXT ASSY 8864276		USED ON T3E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO DIV OF TORQUE CONTROLS, INC UNION CITY, N J		
DR A.S.P.	SCALE 20:1	A. A.S.P. 9/11/63
CH		
APPR		
DATE 9/10/63		
TITLE SHAFT, BALANCE		8864275

HV-28

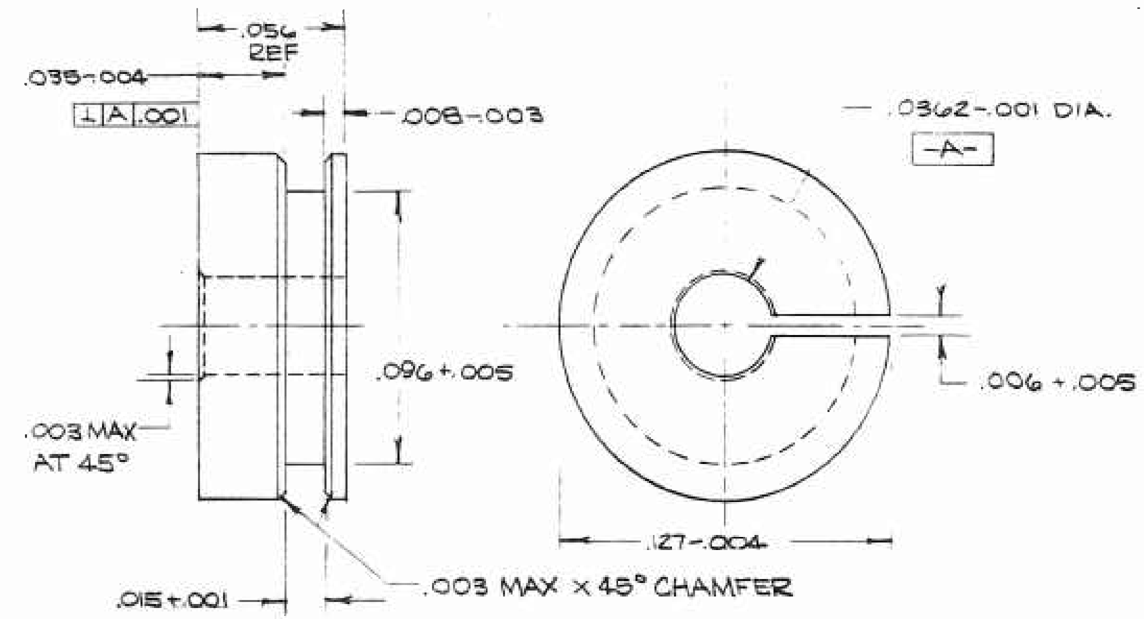


NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- PRESS FIT THE BALANCE & IMPULSE PIN ASSY. OVER SHAFT AND FLUSH AGAINST SHAFT SHOULDER. (SEE NOTES 3 & 4.)
3- BALANCE SHAFT MUST WITHSTAND A MINIMUM TORQUE OF 5 OUNCE INCHES IN EITHER DIRECTION AS SHOWN.
4- BALANCE & IMPULSE PIN ASSY MUST WITHSTAND A MINIMUM LOAD OF 15 POUNDS IN THE DIRECTION SHOWN WITHOUT ANY VISIBLE GAP BETWEEN THE BALANCE & SHAFT SHOULDER.

NEXT ASSY 8864-280		USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR A.S.P.	SCALE 10:1	REVISION	DATE
CH			
APPR			
DATE 9/10/62			
TITLE BALANCE & SHAFT ASSY 8864276			

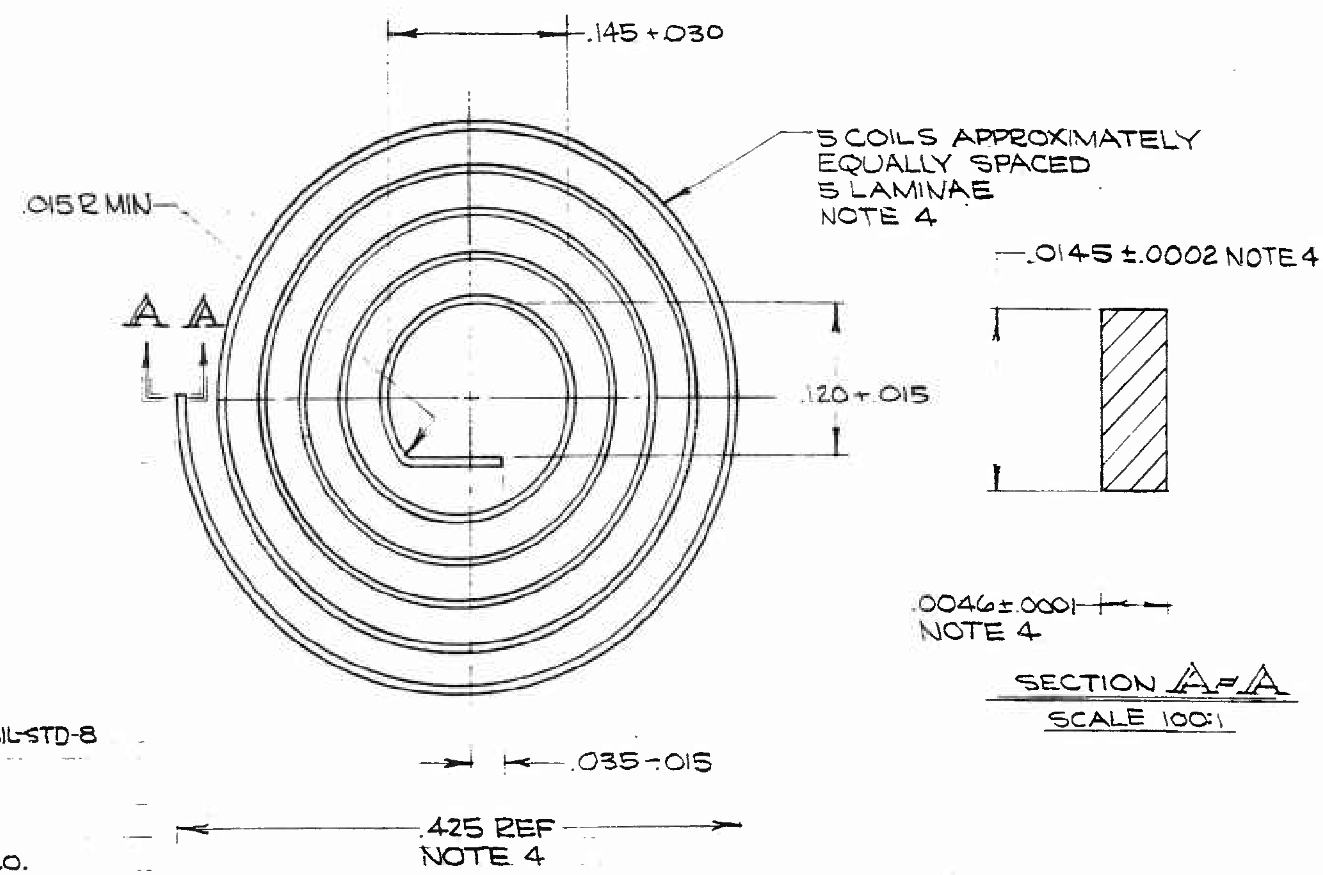
HV-29



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- MATERIAL:-ALUMINUM ALLOY, ROD, 6061-T6, SPEC ASTM B 211.
3- FINISH ALL OVER 125√.
4- ALL INSIDE CORNERS SHARP TO .005R. MAX.

NEXT ASSY 8864279		USED ON T3E2, T4E1, & T5E1	
HAIRSPRING VIBRATING CO. DIV OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR A. S. P.	SCALE 20:1	REVISION	DATE
CH.			
APPR			
DATE 9/11/62			
TITLE HAIRSPRING HUB		NO 8864277	

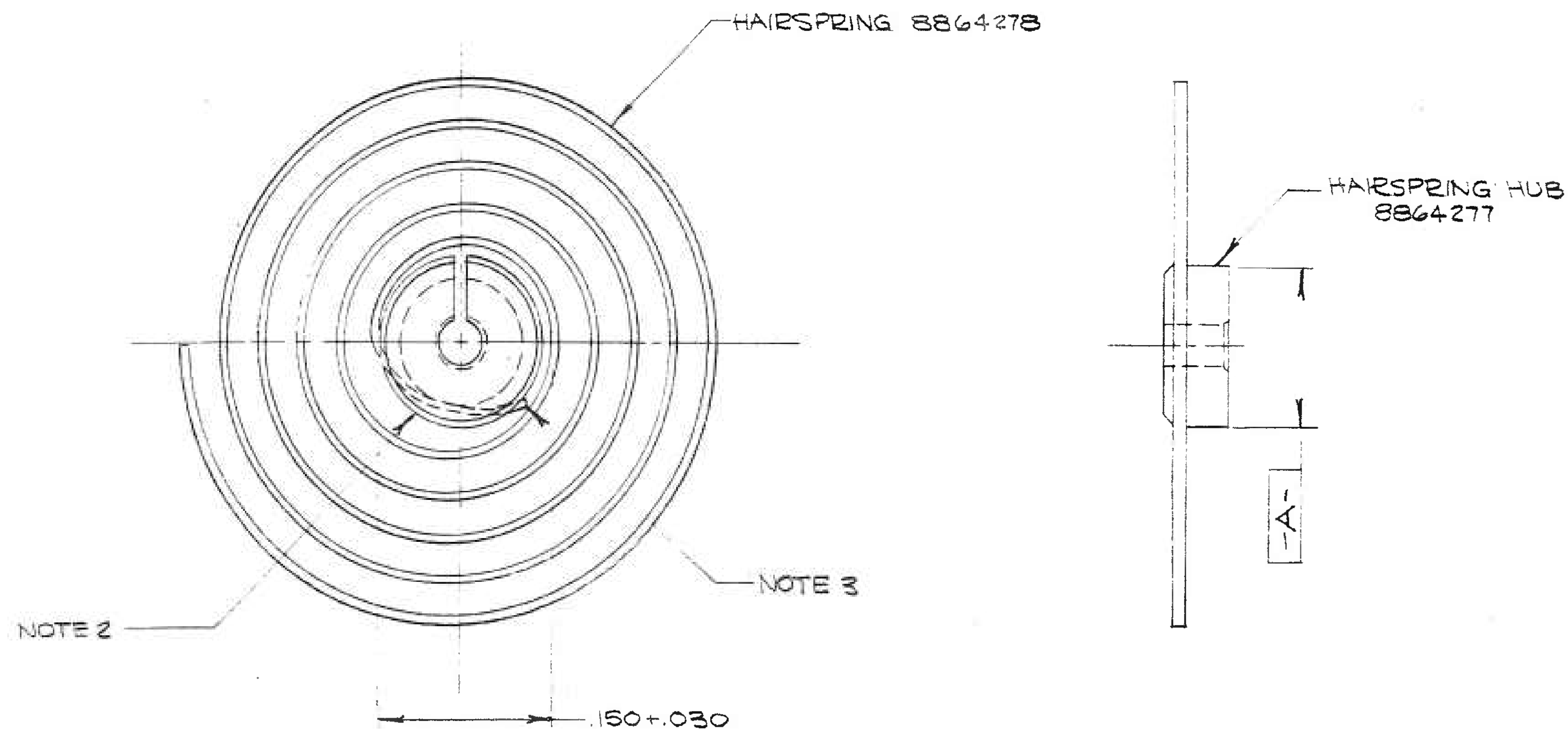
HV-30



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2- APPROVED MATERIALS:
   NI-SPAN-C, A PRODUCT OF INTERNATIONAL NICKEL CO. HUNTINGTON, W. VA.
   ELINVAR EXTRA, A PRODUCT OF INDUSTRIAL PRODUCTS DIV. HAMILTON WATCH CO. LANCASTER, PA.
3- MATERIAL TO PRODUCE A ZERO THERMO-ELASTIC COEFFICIENT.
4- ADVISORY:-MAY BE VARIED TO MEET THE BEAT RATE & TIMING REQUIREMENTS.

NEXT ASSY. 8864279	USED ON. T3E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC UNION CITY, N. J.	
DR A.S.P. SCALE 10:1	REVISION
CH	
APPR	
DATE 9/11/62	
TITLE HAIRSPRING	8864278

HV-31



NOTES:

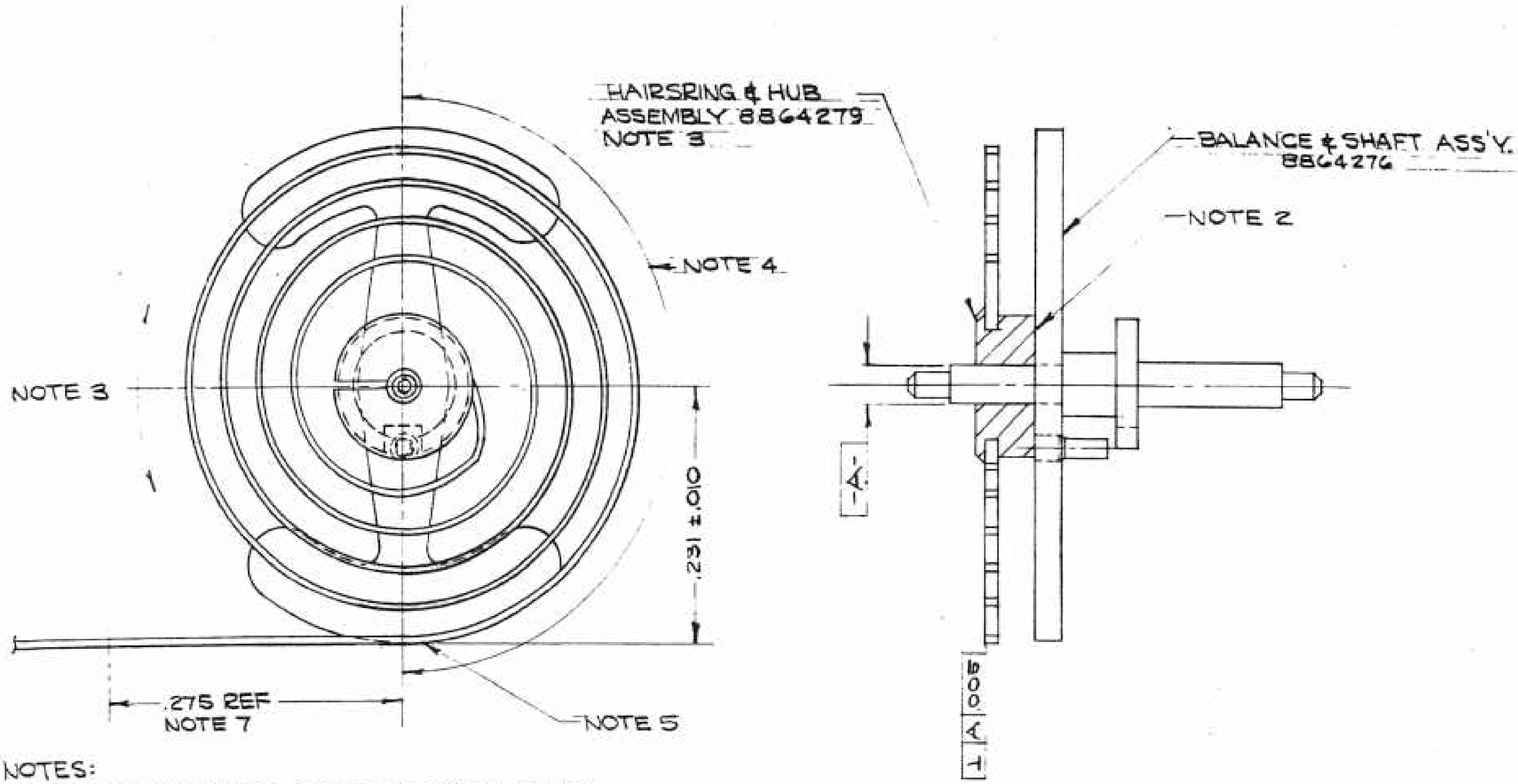
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY

2- CRIMP SECURELY THRU 90° MINIMUM.

3- INNER END OF HAIRSPRING TO BE FLUSH TO .010 MAX ABOVE FLUSH.

NEXT ASSY 8864280		USED ON T3E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO DIV OF TORQUE CONTROLS INC UNION CITY N J		
DR A.S.P.	10:1	REVISION DATE
CH		
APPR		
DATE 9/11/62		
TITLE HAIRSPRING & HUB ASSEMBLY		NO 8864279

HV-32



NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.

2- PRESS FIT HAIRSPRING & HUB ASSEMBLY OVER SHAFT AND FLUSH AGAINST BALANCE. MUST BE NO VISIBLE SEPARATION. (SEE NOTE 3)

3- HAIRSPRING HUB MUST WITHSTAND A MINIMUM TORQUE OF 1½ OUNCE INCHES IN EITHER DIRECTION WITHOUT SIGNS OF SLIPPAGE.

4- HAIRSPRING MUST EMERGE FROM HUB IN AREA INDICATED.

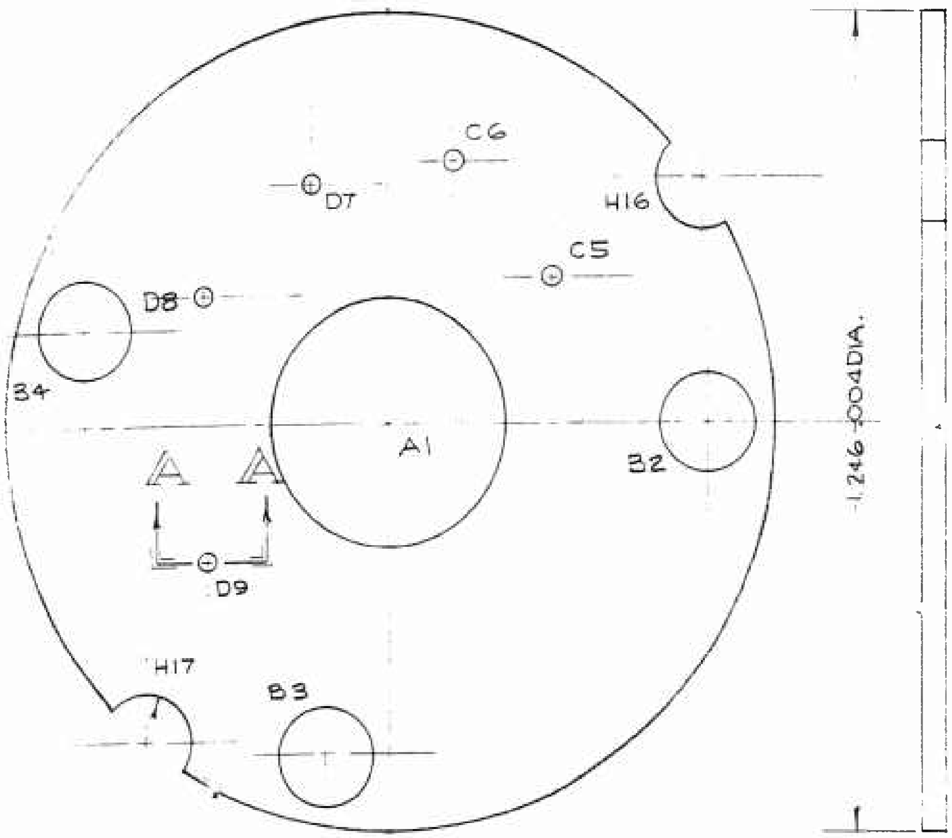
5- COILS TO BLEND WITH OUTER TANGENT.

6- COILS TO HAVE SPIRALLING APPEARANCE WHEN ASSEMBLY IS ROTATED.

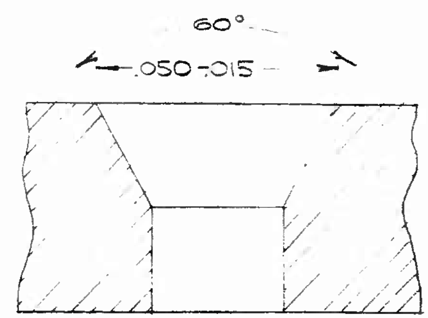
7- ADVISORY: - 4 TURNS TO TANGENT. EFFECTIVE TANGENT APPROX. .275.

NEXT ASSY. 8864282		USED ON T8E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A. S. P.	SCALE 10:1	REVISION	DATE
CH.			
APPR			
DATE 9/11/62			
TITLE BALANCE ASSEMBLY		NO. 8864280	

HV-33



HOLE DATA				
HOLE	DIA.	TZD ⊕A B	BASIC X	BASIC Y
A1	.375 +.005	-A-	DATUM	DATUM
B2	.1400+.0005	.0016	.5143	DATUM
B3	.1400+.0005	.0016	-.0861	-.5073
B4	.1400+.0005	.0016	-.4917	+.1500
C5	.0280+.0008	.0016	+.2614	+.2191
C6	.0280+.0008	.0016	+.1066	+.3923
D7	.0245+.0008	.0016	-.1234	+.3592
D8	.0245+.0008	.0016	-.2938	+.1939
D9	.0245+.0008	.0016	-.2927	+.2066
H16	.0700+.0008R	.0016	+.3077	+.3633
H17	.0700+.0008R	.0016	-.3964	-.4828



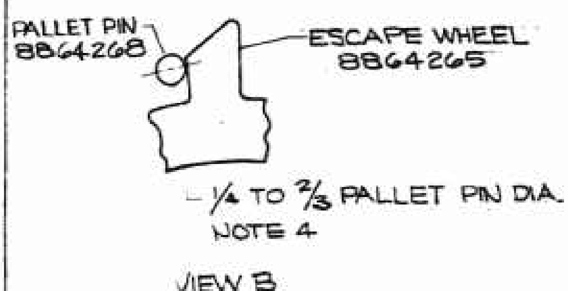
SECTION A-A SEE NOTE 4
HOLES C&D
SCALE 40/1

NOTES:

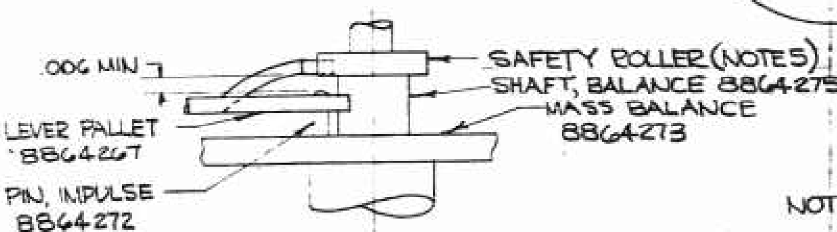
1. SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2. MATERIAL:-BRASS, STRIP, ½- HARD ALLOY #5, SPEC. ASTM B121
3. FINISH ALL OVER 125
4. ADVISORY:- SECTION A-A INDICATES METHOD FOR REDUCTION OF PIVOT FRICTION
5. ADVISORY:- CUTOUTS H16 & H17 FACILITATE AUTOMATIC ASSEMBLY TECHNIQUE

NEXT ASSY 8864282	USED ON T3E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO DIV OF TORQUE CONTROLS INC UNION CITY, N. J.	
DR A.S.P. SCALE 5:1	REVISION A. ASP DATE 3/11/63
CH	
APPR	
DATE 8/5/62	
TITLE PLATE #2	NO 8864281

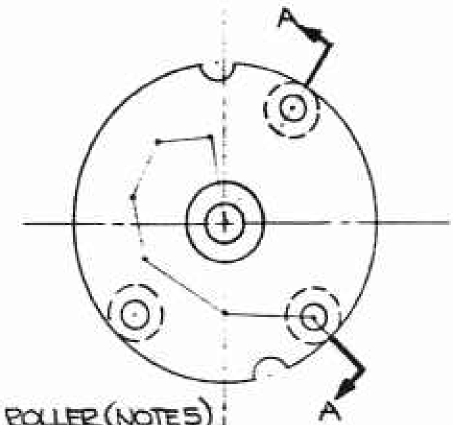
HV-34

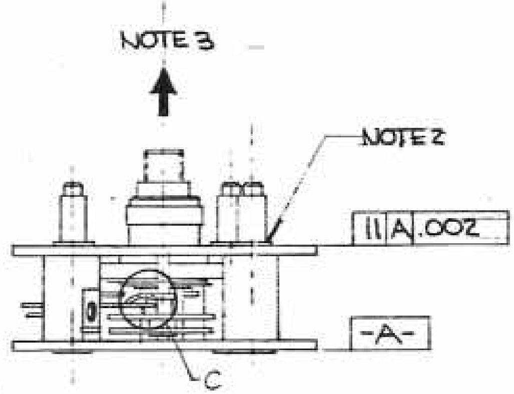


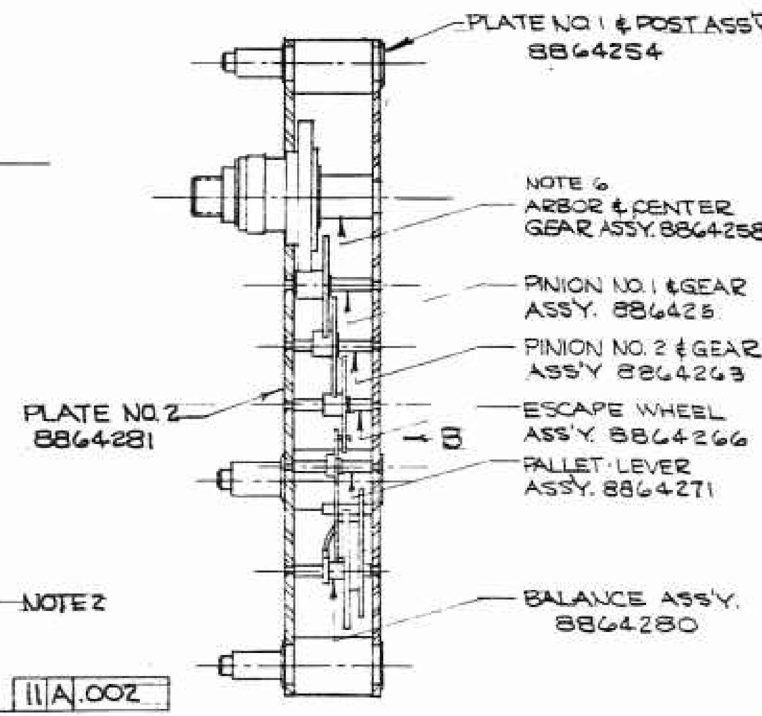
VIEW B



VIEW C





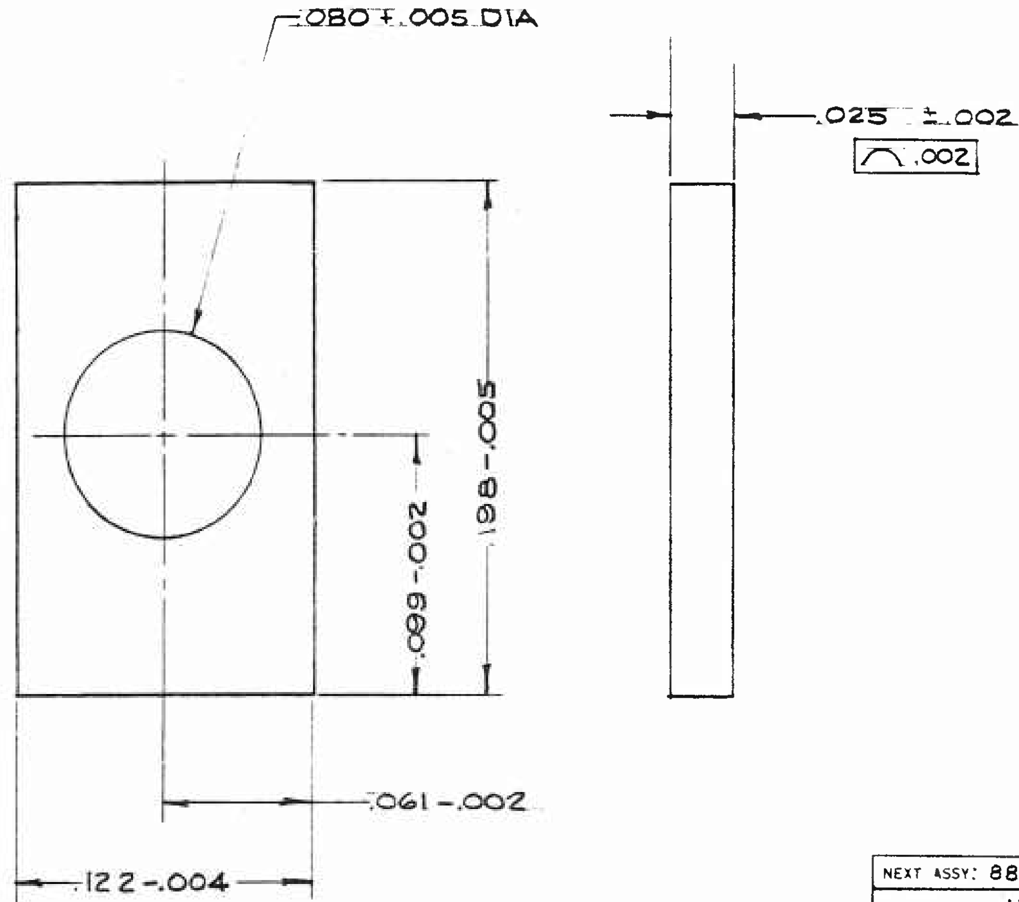


SECTION A-A

NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- SECURE PLATE NO. 2 TO POSTS BY ANY SUITABLE METHOD. (SEE NOTE 3)
3- PLATE NO. 2 MUST WITHSTAND A 25LB. MINIMUM. PULL TEST IN THE DIRECTION SHOWN WITHOUT ANY VISIBLE GAP BETWEEN THE PLATE & ANY POST SHOULDER.
4- CLEARANCE BETWEEN PALLET PIN & ESCAPE WHEEL ROOT MUST BE BETWEEN 1/4 TO 2/3 OF THE PALLET PIN DIAMETER AS SHOWN IN VIEW B WHEN BALANCE IS TURNED 90° IN EITHER DIRECTION FROM DEAD BEAT.
5- ADJUST THE PALLET GUARD FINGER TO OBTAIN A MINIMUM ENGAGEMENT OF 1/2 THE FINGER HEIGHT WITH THE SAFTEY ROLLER OF THE BALANCE SHAFT WHEN THE ASSEMBLY IS BOTH IN THE UPRIGHT & INVERTED POSITIONS. SEE VIEW C.
6- BEFORE ASSEMBLY, LIGHTLY DIP EACH COMPONENT & SUB-ASSEMBLY IN A 10% SOLUTION (BY VOLUME) OF "VYDAX" AR DISPERSED IN FREON TF SOLVENT.- APPROVED SOURCE: DUPONT ORGANIC CHEMICAL DEPT., DELAWARE.

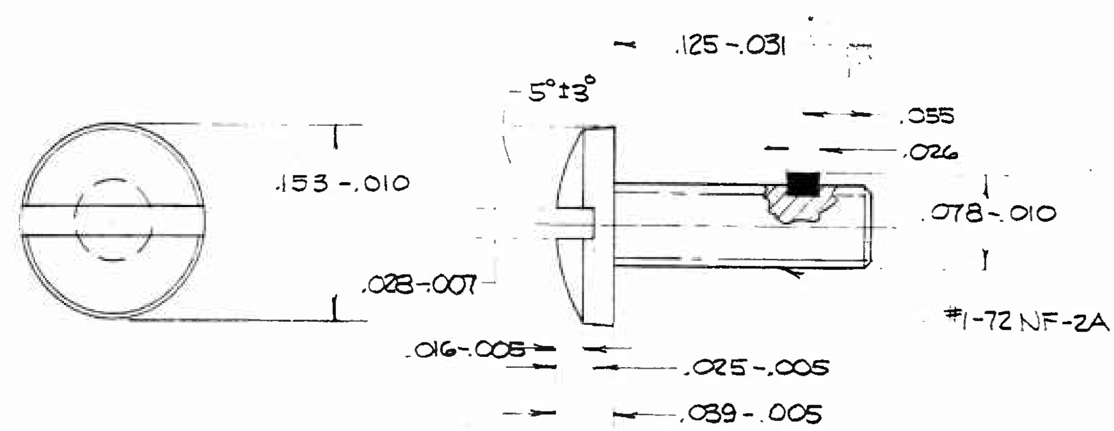
NEXT ASSY 8864288		USED ON T8E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS INC. UNION CITY N.J.			
DR A. S. P.	SCALE 2:1	REVISION	DATE
CH		A. B.P.	9/1/63
APPR		B T.F.S	3-25-63
DATE 9/11/62		C T.F.S.	6-4-63
TITLE PLATES NO. 1 & 2 ASS'Y. 8864282			



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2-MATERIAL:- BRASS, STRIP, ½ OR ¾ HARD, SPEC. ASTM B36.
3-FINISH ALL OVER 125√

NEXT ASSY: 8864288		USED ON: T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR A.S.P.	SCALE 5:1	REVISION	DATE
CH.			
APPR			
DATE 8/5/62			
TITLE HAIRSPRING LOCK		NO 8864283	

HV-36



NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY

2-MATERIAL:- BRASS

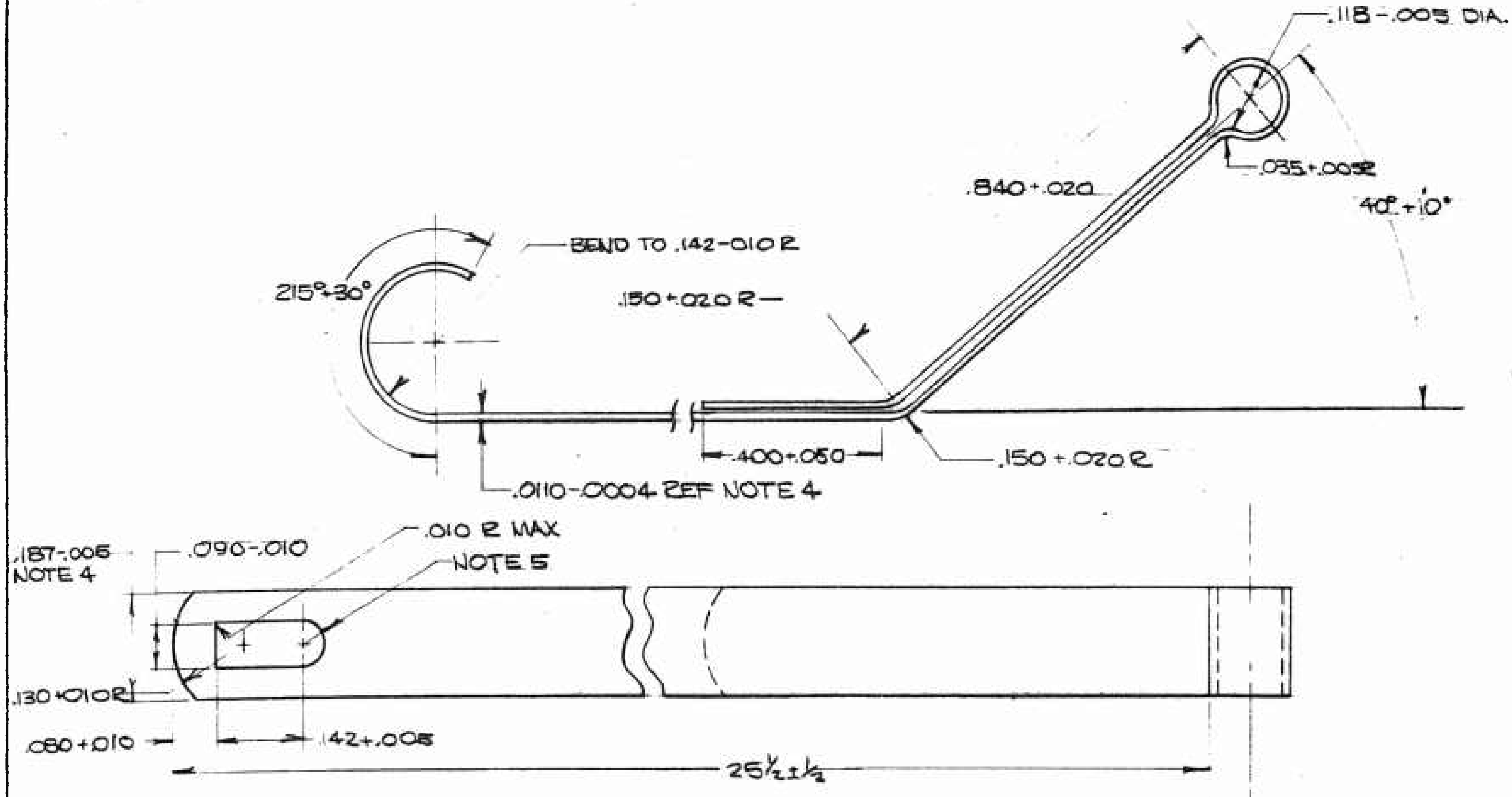
3-NYLOCK FEATURE PER:

THE NYLOCK CORP.
611 INDUSTRIAL AVE.
PARAMUS, N.J.
PART NO. M36B172-2P

4- SCREW CONFORMS TO A.S.A. B18.6 1947
EXCEPT FOR THE ADDITION OF THE NYLON PELLET.

NEXT ASSY 8864288	USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS INC. UNION CITY, N.J.		
DR A.S.P.	SCALE NONE	REVISION / DATE
CH		
APPR		
DATE 9/11/62		
TITLE BINDING HEAD MACHINE SCREW (SELF-LOCKING	NO. 8864284	

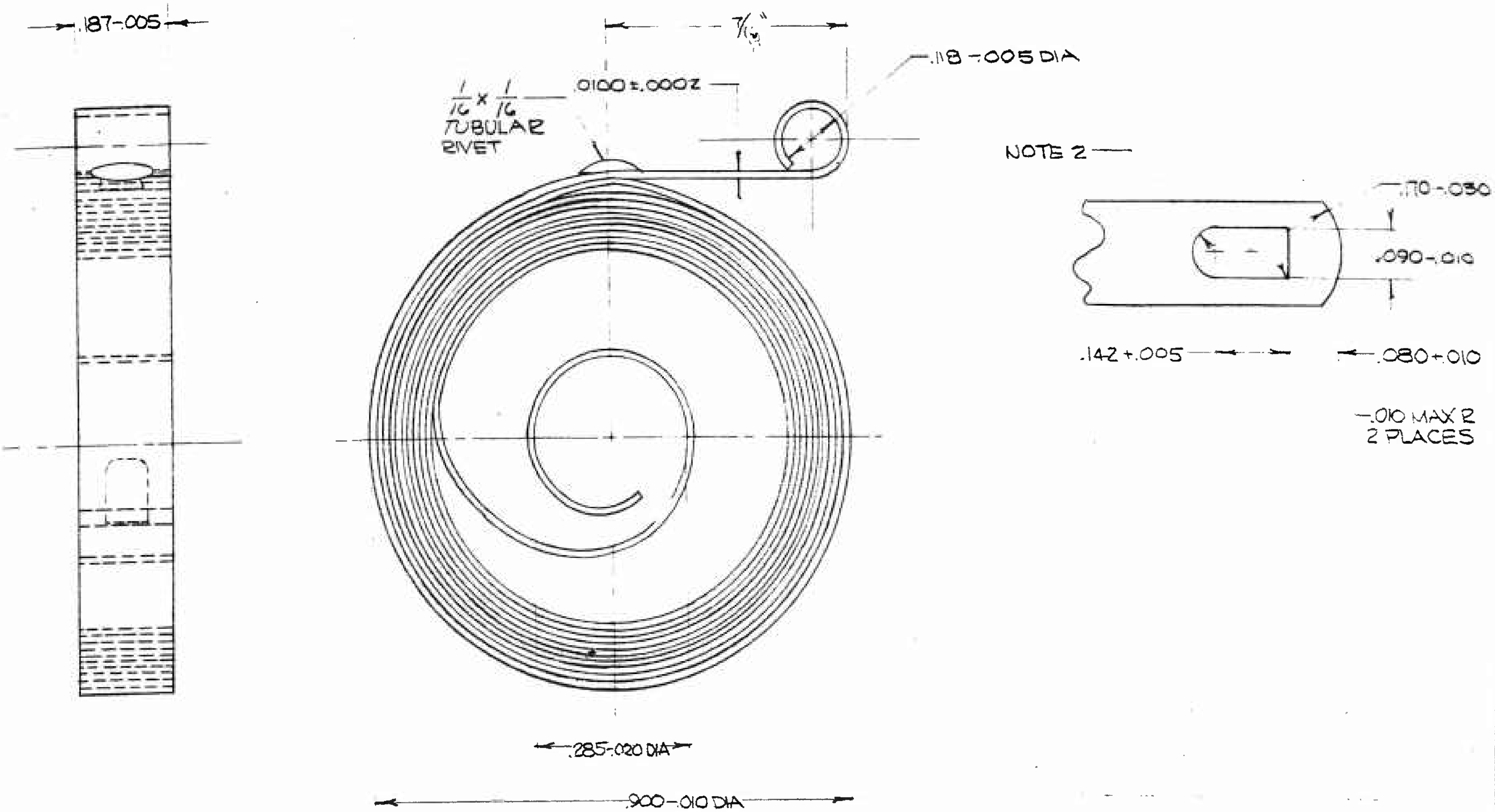
HY-37



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- MATERIAL: 17-7 PH STAINLESS STEEL SPEC. AMS 5529 A
HEAT TREAT TO OBTAIN THE FOLLOWING PHYSICAL PROPERTIES:
TENSILE 230,000 P.S.I. MIN; ELONGATION 1% MIN IN 2 INCHES.
HARDNESS 49 RC MIN.
3- TORQUE AT ½ TURN BACK FROM FULL WOUND - 23 OZ. IN. MAX.
TORQUE AT 1½ TURNS BACK FROM FULL WOUND - 16 OZ. IN. MIN.
4- ADVISORY: MAY BE VARIED TO MEET TORQUE & TIMING REQUIREMENTS.
5- RADIUS EQUAL TO ONE-HALF WIDTH.

NEXT ASSY 8864288	USED ON T3E2, T4E1 & T5E1		
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC. UNION CITY, N J			
DR. A.S.P.	SCALE 5:1	REVISION	DATE
CH		A TFS	6-4-63
APPR			
DATE 9/11/62			
TITLE MAINSPRING	8864285		

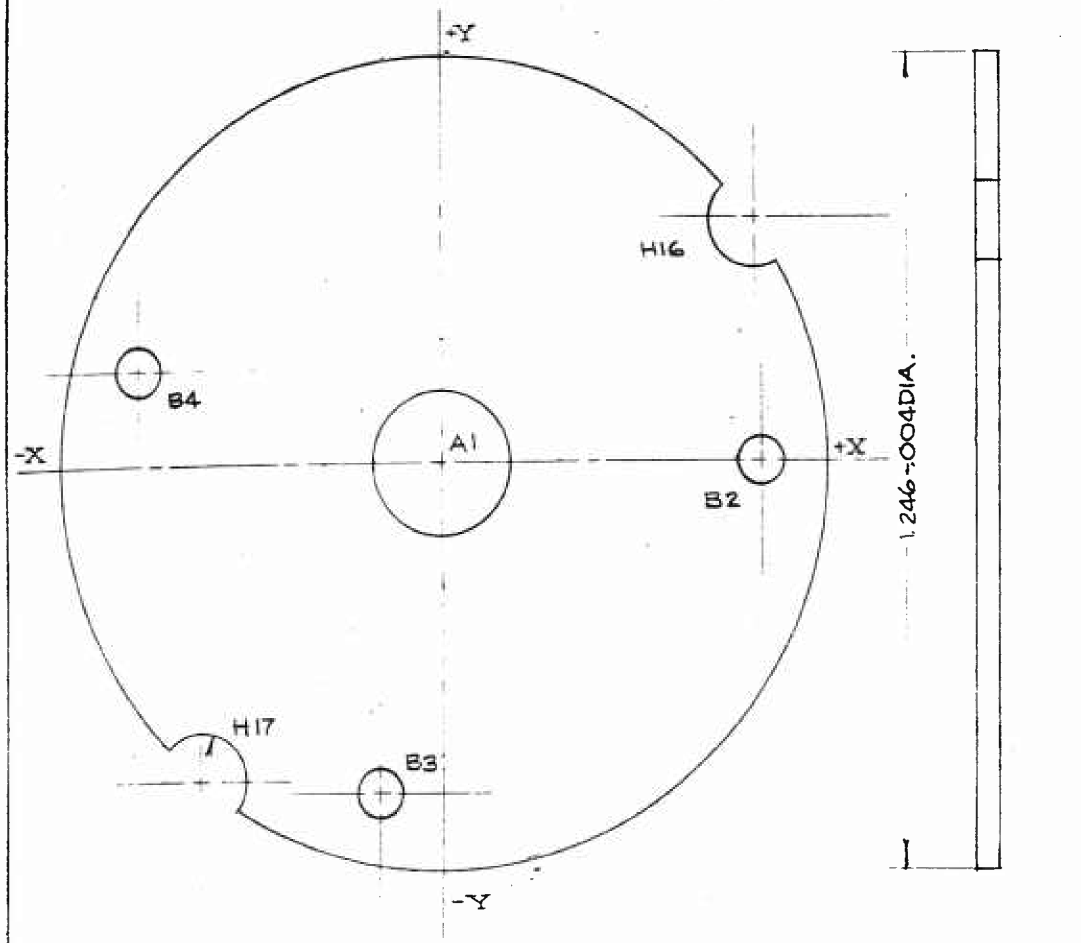
HV-39



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2- RADIUS EQUAL TO ½ WIDTH.
3- SEE 8864285 FOR SPECIFICATIONS.
4- APPROVED SOURCE:
SANDVICK STEEL INC.
FAIRLAWN, N.J.
PART NO. 185-01030

NEXT ASSY 8864288		USED ON T3E2, T4E1 & T5E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J			
DR. A.S.P.	SCALE 5:1	REVISION	DATE
CH		A 7.7S.	6-4-63
APPR			
DATE 9/11/62			
TITLE MAINSPRING ALTERNATE		8864286	

HV-40



—NOTE 5

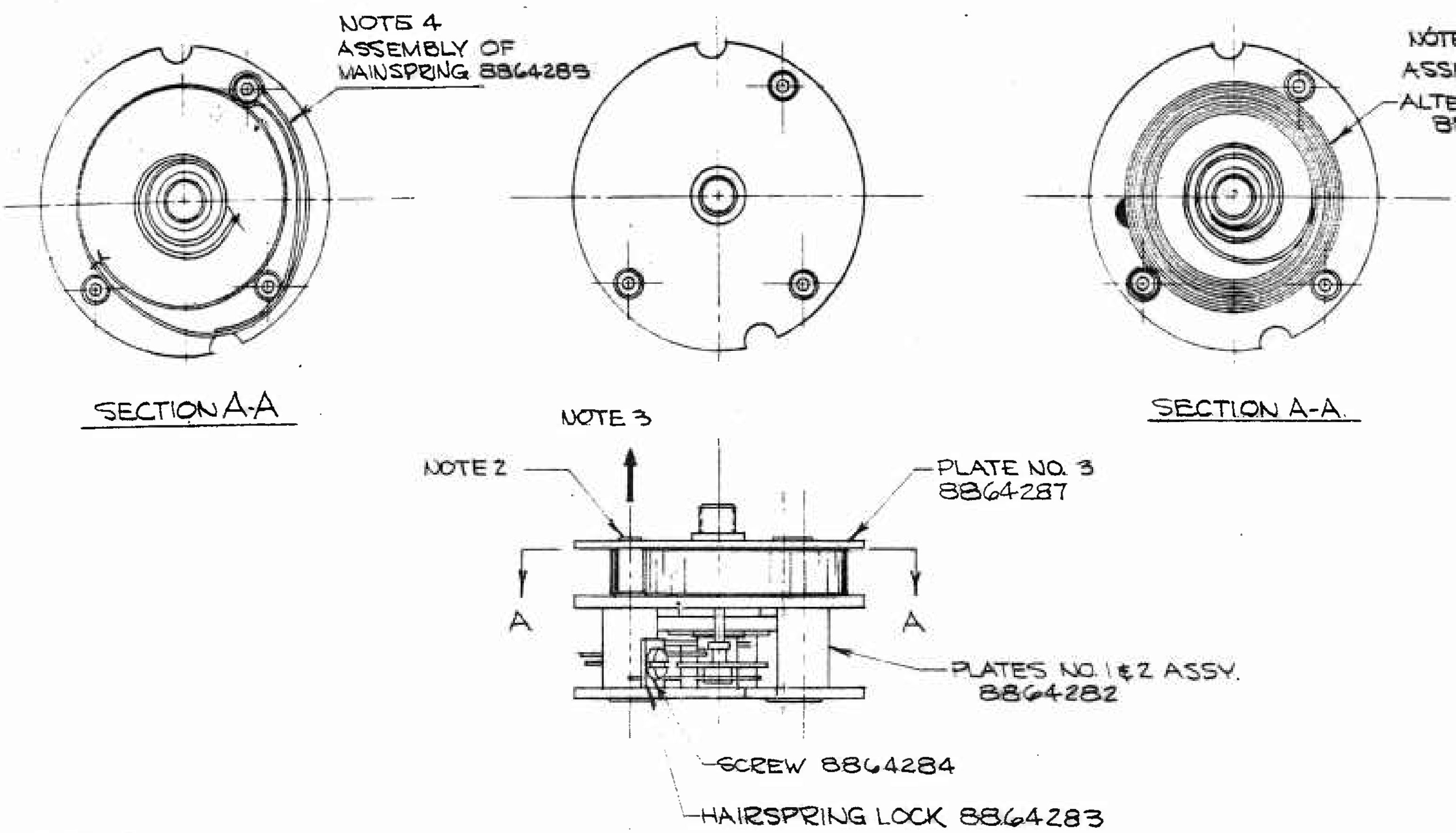
HOLE DATA				
HOLE	DIA.	TZD ⌖ A B	BASIC	
			X	Y
A1	.2200 +.0005	-A-	DATUM	DATUM
B2	.0707 +.0005	.0016	+.5143	DATUM
B3	.0707 +.0005	.0016	-.0861	-.5073
B4	.0707 +.0005	.0016	-.4917	+.1500
H16	.0700 +.0008 R	.0016	+.5077	+.3633
H17	.0700 +.0008 R	.0016	-.3964	-.4828

NOTES:

1. SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2. MATERIAL-BRASS, STRIP, ½ HARD, ALLOY #5, SPEC. ASTM B121
3. FINISH ALL 125√
4. ADVISORY:- CUTOUTS H16 & H17 FACILITATE AUTOMATIC ASSEMBLY TECHNIQUE.

NEXT ASSY 8864288	USED ON T5E2, T4E1 & T5E1
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS INC. UNION CITY N.J.	
DR SCALE 5:1	REVISION DATE
CH	
APPR	
DATE 8/3/62	
TITLE PLATE #3	NO. 8864287

HV-41



NOTES

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.

2- SECURE PLATE NO. 3 TO POSTS BY ANY SUITABLE METHOD. (SEE NOTE 3)

3- PLATE NO. 3 MUST WITHSTAND A 20 LB MINIMUM PULL TEST IN THE DIRECTION SHOWN WITHOUT ANY VISIBLE GAP BETWEEN THE PLATE AND ANY POST SHOULDER.

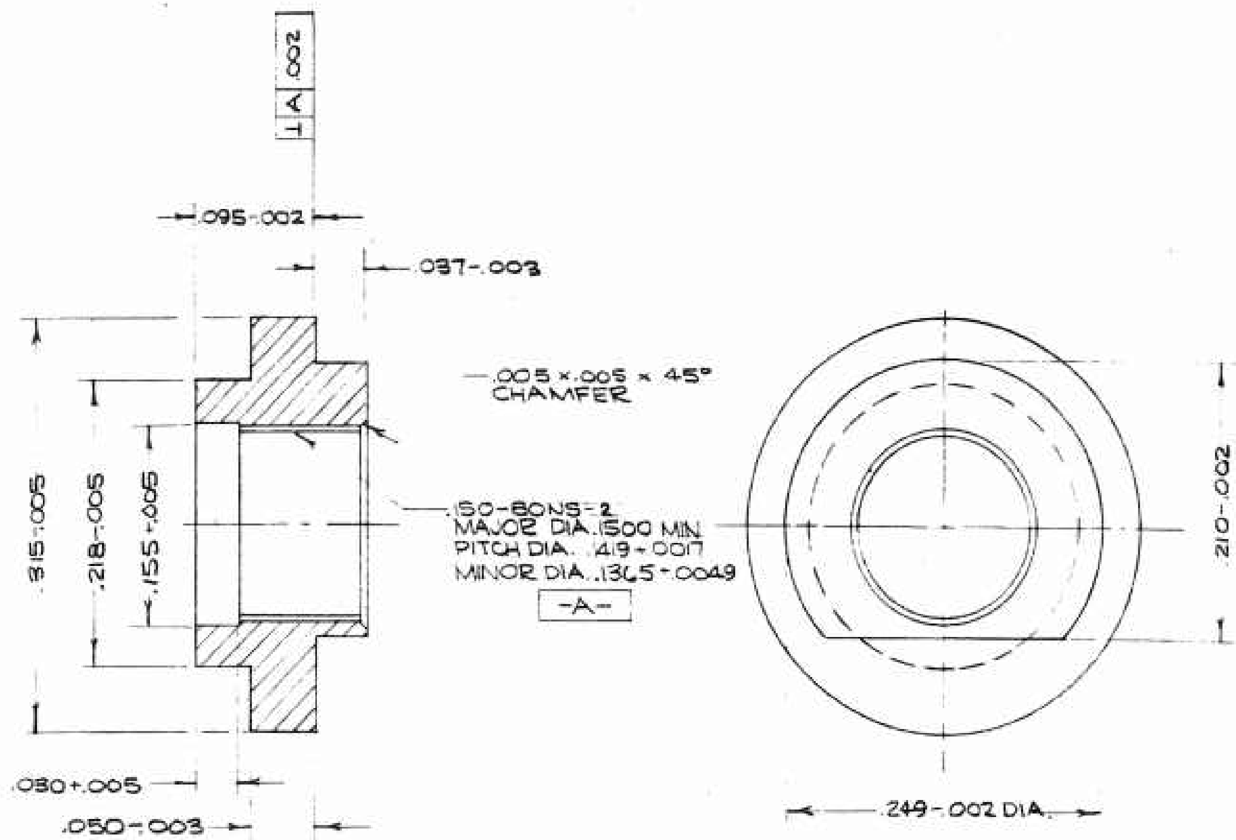
4- MAINSPRING TO BE ASSEMBLED AS SHOWN IN SECTION A-A.

5- BEFORE ASSEMBLY, LIGHTLY DIP MAINSPRING & PLATE NO. 3 IN A 10% SOLUTION (BY VOLUME) OF "VYDAX" AR, DISPERSED IN FREON TF SOLVENT.

APPROVED SOURCE: DUPONT, ORGANIC CHEM. DEPT. DELAWARE.

NEXT ASSY. 8864297		USED ON T5E1	
NEXT ASSY. 8864298		USED ON T4E1	
NEXT ASSY 8864299		USED ON T3E2	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A. S. P.	SCALE 2:1	REVISION	DATE
CH			
APPR.			
DATE 9/12/62			
TITLE PLATES NO. 1, 2 & 3 ASS'Y.		NO. 8864288	

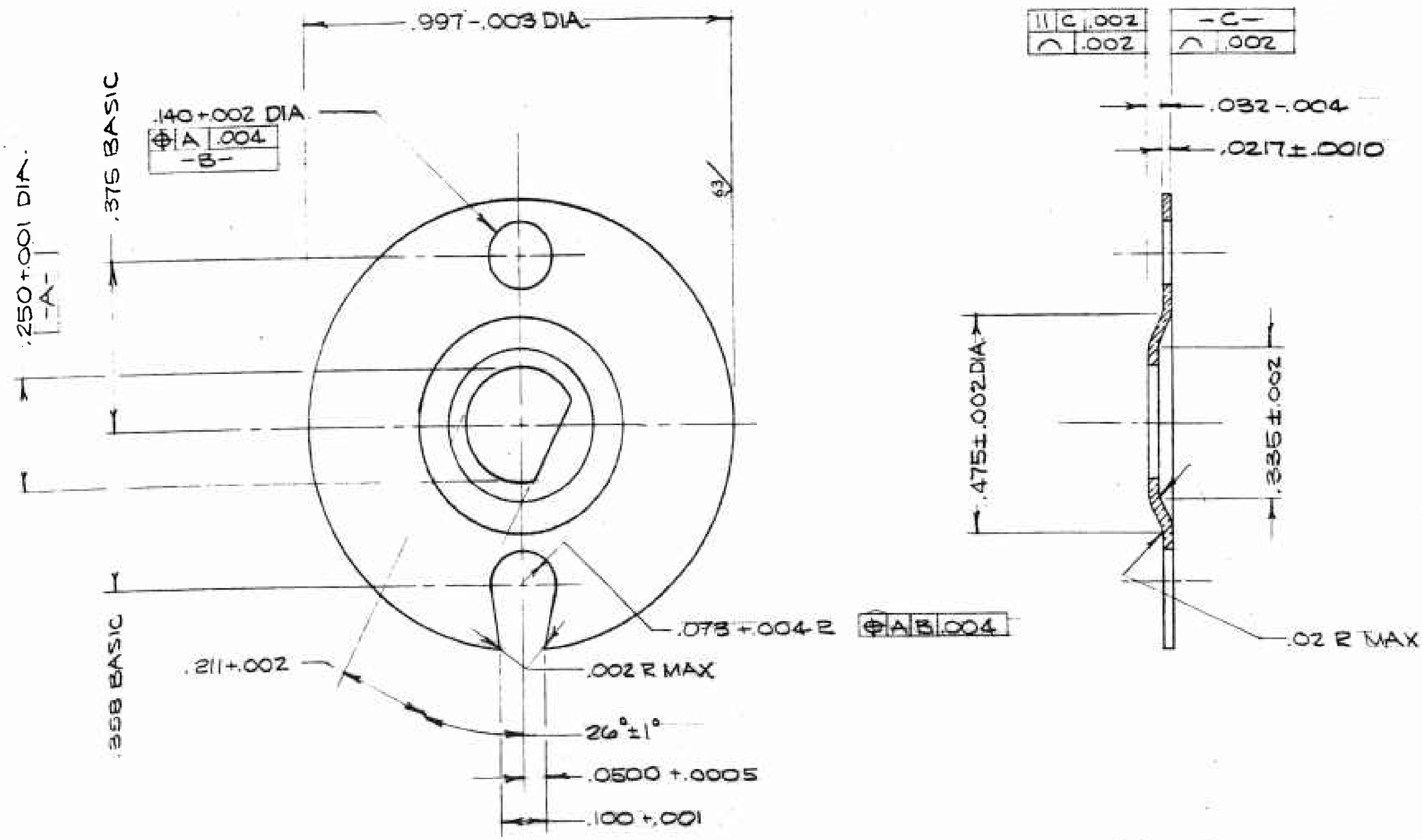
HV42



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- MATERIAL: BRASS, ROD, ½ HARD, SPEC. ASTM B16
3-FINISH ALL OVER 125√

NEXT ASSY: 8864291	USED ON: T5E1
NEXT ASSY 8864295	USED ON T4E1
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.	
DR. A. S. P. SCALE 10:1	REVISION / DATE
CH	A T. F S 3-25-63
APPR	
DATE 9/12/62	
TITLE NUT, MOVEMENT T4E1 & T5E1	NO. 8864289

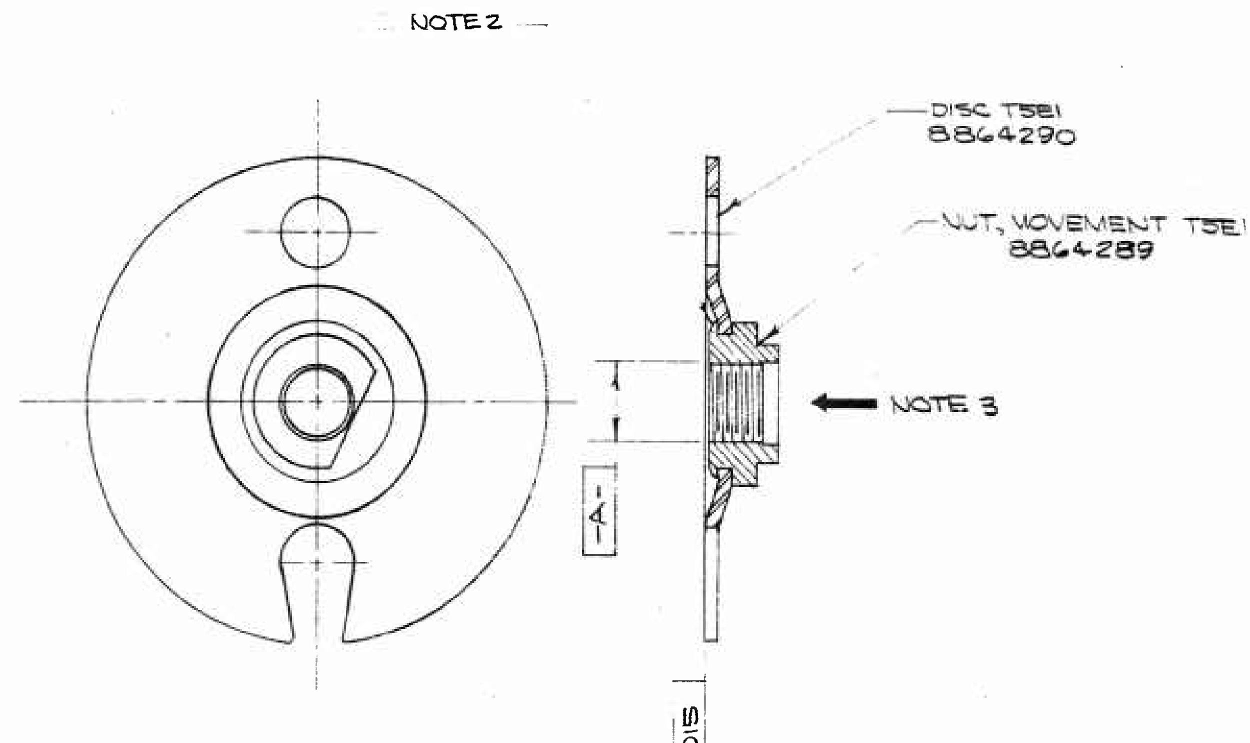
4V43-



NOTES:
1-SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2-MAT'L: BRASS, STRIP, SPRING HARD, ALLOY #6, SPEC ASTM B36.

NEXT ASSY 8864291		USED ON T5E1	
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A.S.P.	SCALE 4:1	REVISION	DATE
CH.		A T.F.S.	3-25-63
APPR.			
DATE 9/12/62			
TITLE DISC, T5E1		8864290	

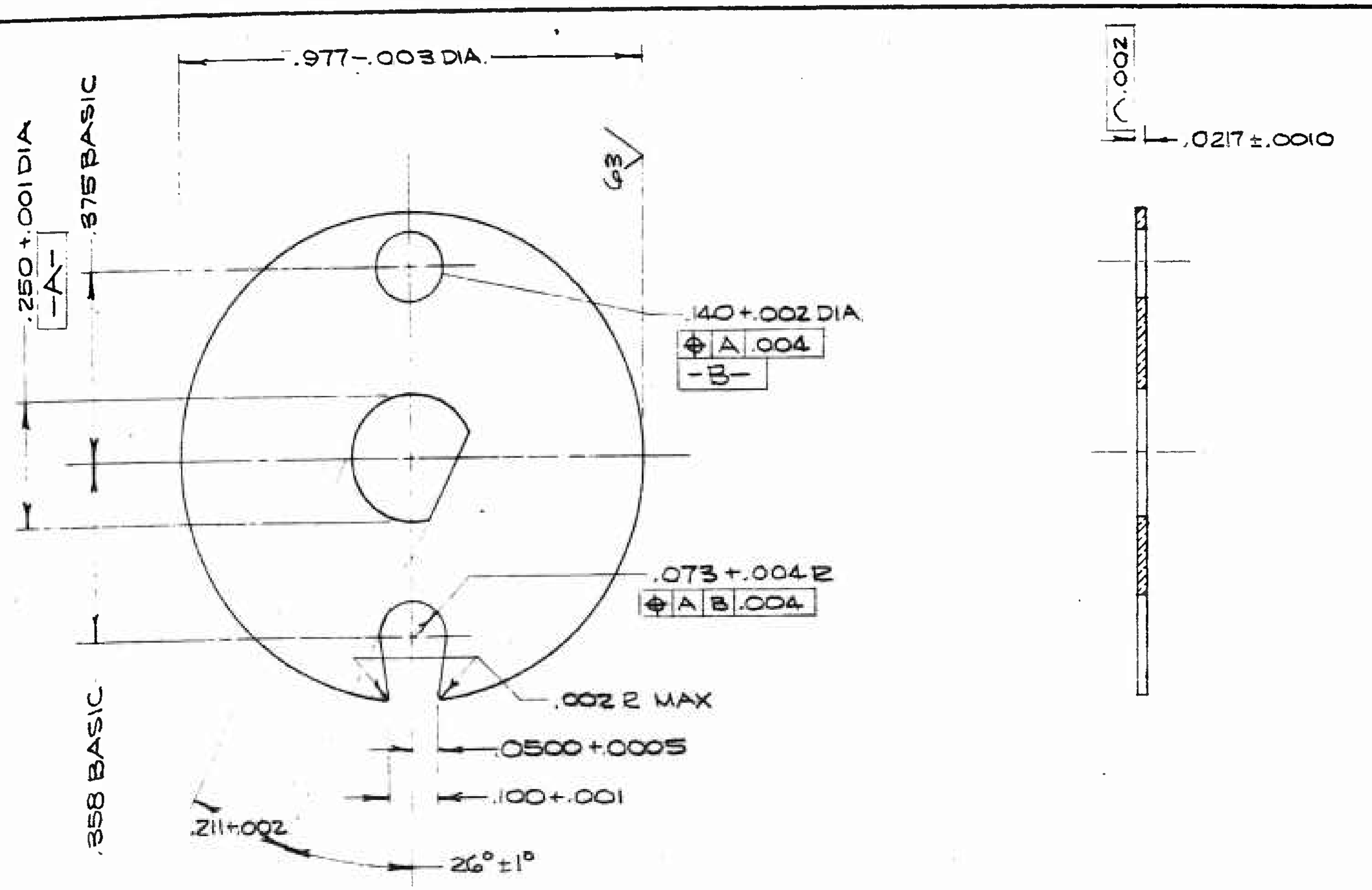
HV-44



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2-SECURE THE DISC TO THE HUB BY ANY SUITABLE MEANS. (SEE NOTE 3)
3-DISC MUST WITHSTAND A MINIMUM LOAD OF 20 LBS. IN THE DIRECTION SHOWN.

NEXT ASSY 8864297	USED ON T5E1
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.	
DR. A.S.P. SCALE 4:1	REVISION / DATE
CH	A, A.S.P. 3/11/63
APPR.	
DATE 9/12/62	
TITLE DISC, ASSEMBLY, T5E1	NO. 8864291

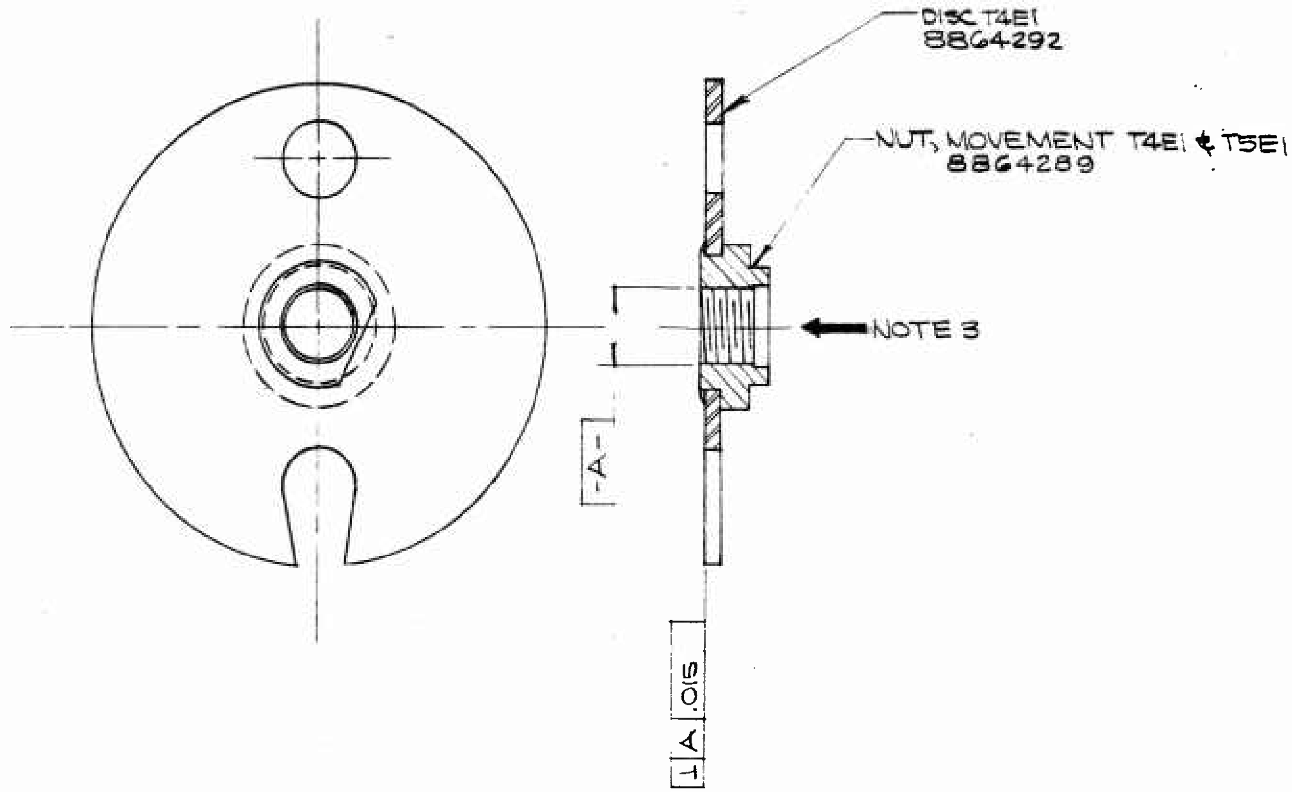
HY45



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2-MATERIAL:-BRASS, STRIP, SPRING HARD, ALLOY #6, SPEC. ASTM B36

NEXT ASSY 8864293		USED ON T4E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A.S.P.	SCALE 4:1	REVISION	DATE
CH			
APPR			
DATE 9/12/63			
TITLE DISC T4E1		NO. 8864292	

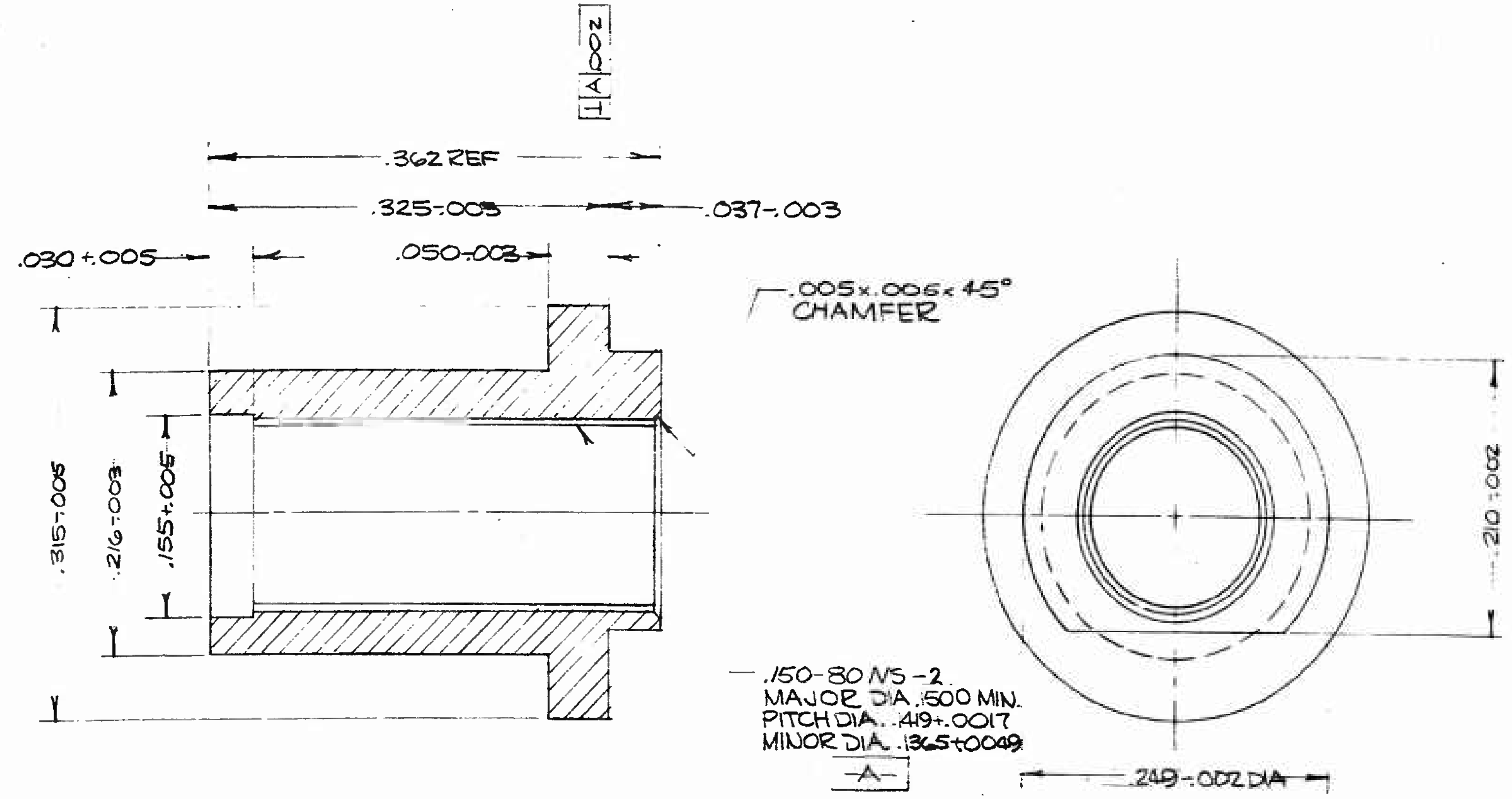
HV-46



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- SECURE THE DISC TO THE HUB BY ANY SUITABLE MEANS. (SEE NOTE 3)
3- DISC MUST WITHSTAND A MINIMUM LOAD OF 20 LBS. IN THE DIRECTION SHOWN.

NEXT ASSY 8864298		USED ON T4E1	
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A.S.P.	SCALE 4:1	REVISION	DATE
CH.			
APPR.			
DATE 9/12/62			
TITLE DISC ASSEMBLY, T4E1		NO. 8864293	

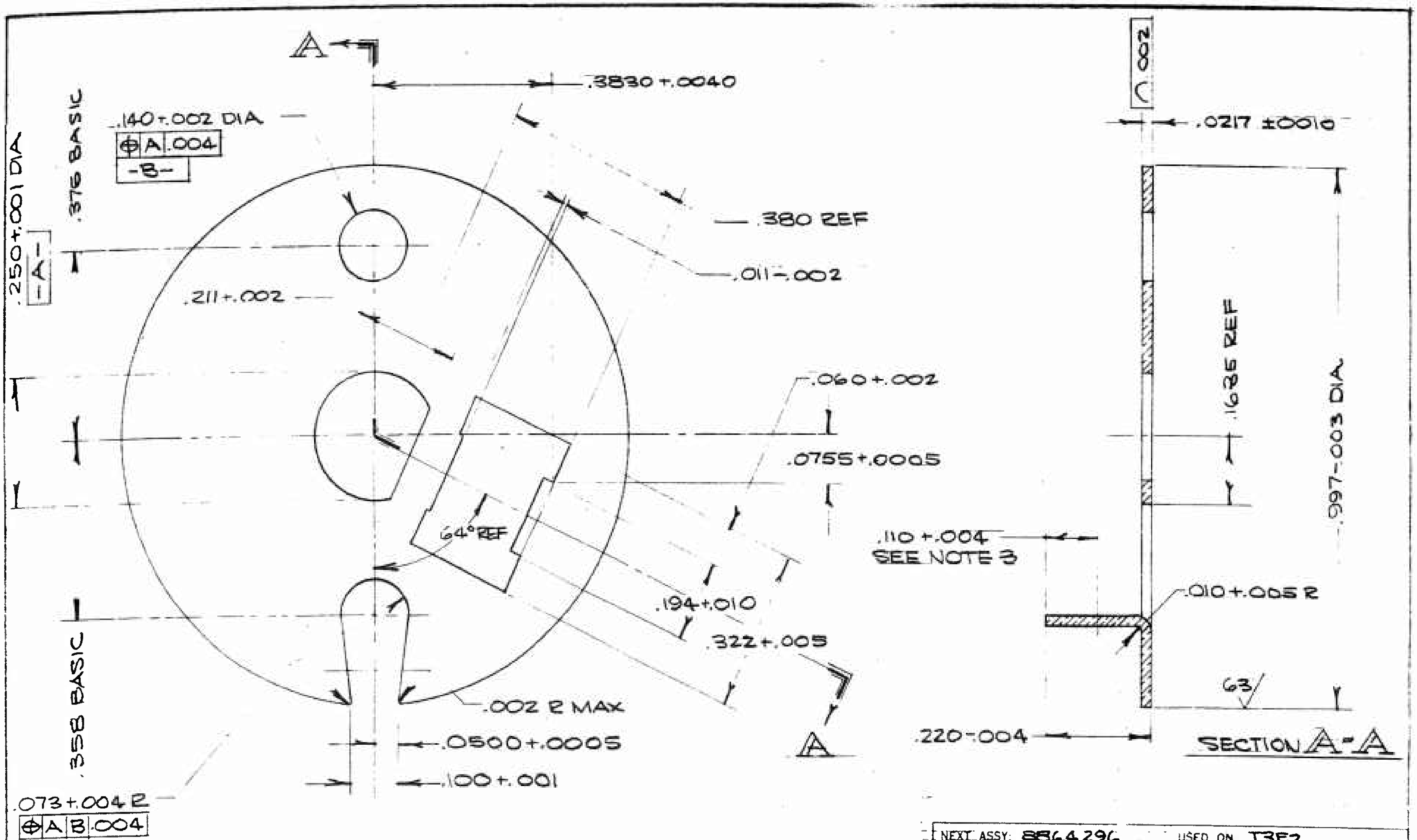
HV-47



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- MATERIAL: BRASS, ROD, 1/2 HARD SPEC ASTM B16.
3- FINISH ALL OVER 125

NEXT ASSY 8864296	USED ON T3E2		
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR A.S.P.	SCALE 10:1	REVISION	DATE
CH.		A A.S.P.	3/11/63
APPR.		B T.F.S.	3-25-63
DATE 9/12/62			
TITLE NUT, MOVEMENT T3E2		NO 8864294	

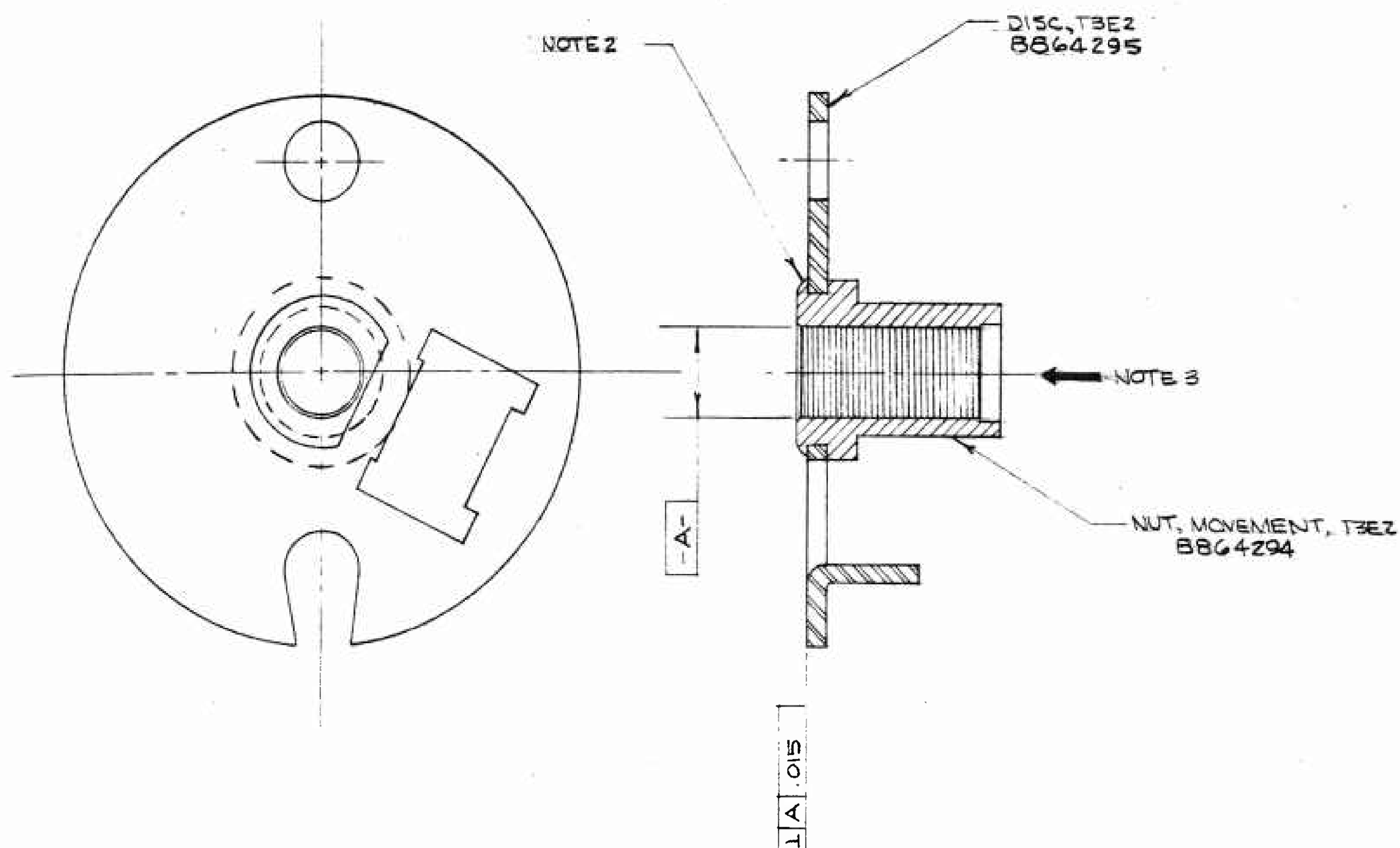
HV-48



NOTES:
1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- MATERIAL:-BRASS, STRIP, SPRINGHARD, ALLOY #6 SPEC ASTM B36
3-THIS AREA MUST BE HELD TO CO-ORDINATE DIMENSIONS.

NEXT ASSY: 8864296	USED ON T3E2		
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A.S.P.	SCALE 5:1	REVISION	DATE
CH.		1. A.S.P.	3/11/63
APPR			
DATE 9/12/62			
TITLE DISC, T3E2		NO. 8864295	

HV-49

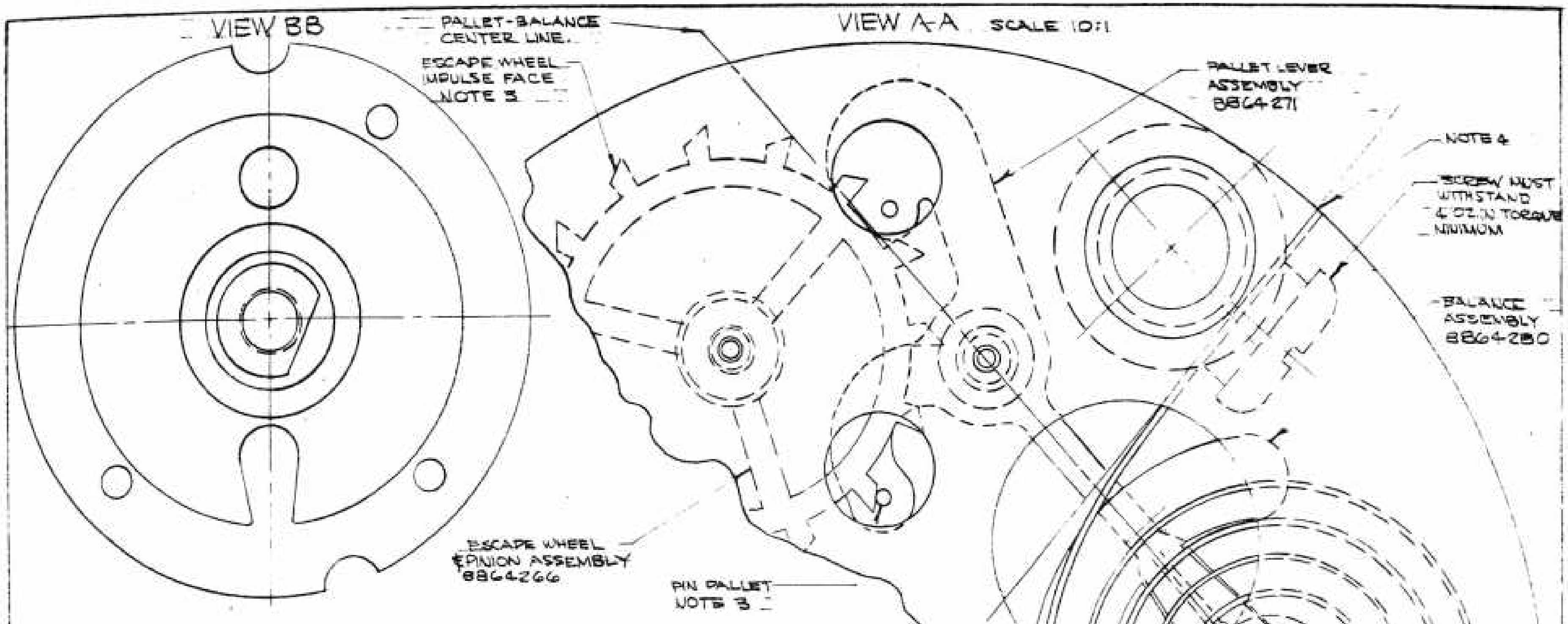


NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.
2- SECURE THE DISC TO THE HUB BY ANY SUITABLE MEANS. (SEE NOTE 3)
3- DISC MUST WITHSTAND A MINIMUM LOAD OF 20 LBS.
IN THE DIRECTION SHOW.

NEXT ASSY. 8864299	USED ON T3E2		
HAIRSPRING VIBRATING CO DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A. S. P.	SCALE 5:1	REVISION	DATE
CH.			
APPR.			
DATE 9/12/62			
TITLE DISC ASSEMBLY T3E2	NO. 8864296		

HV-50



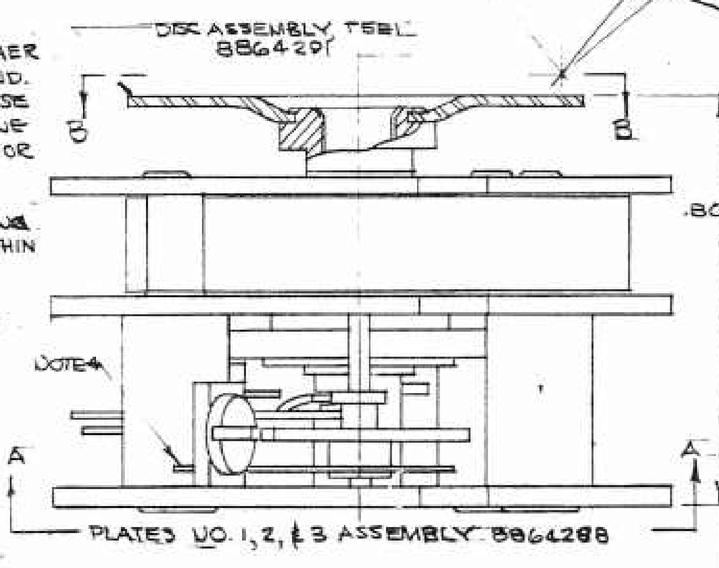
NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.

2-ADJUST BEAT RATE ON ANY STANDARD WATCH BEAT RATE RECORDER OR OTHER MEANS TO 50 ± .25 BEATS PER SECOND. BEAT RATE MUST BE HELD WITHIN THESE LIMITS FOR A MINIMUM OF ONE AND ONE HALF (1 1/2) TURNS FROM FULL WIND OR 144 SECONDS.

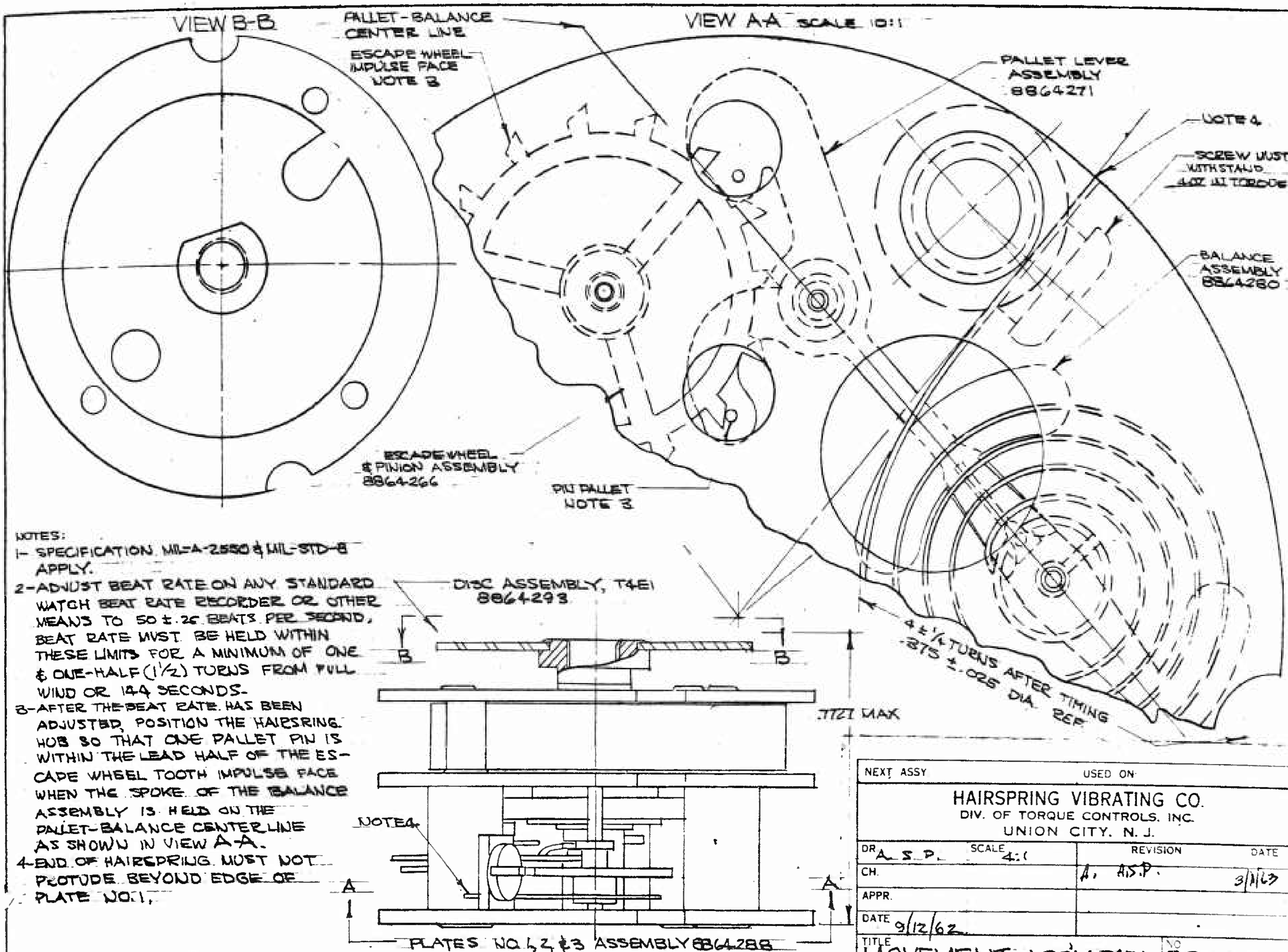
3-AFTER THE BEAT RATE HAS BEEN ADJUSTED, POSITION THE HAIR SPRING HUB SO THAT ONE PALLET PIN IS WITHIN THE LEAD HALF OF THE ESCAPE WHEEL TOOTH IMPULSE FACE WHEN THE SPOKE OF THE BALANCE ASSEMBLY IS HELD ON THE PALLET-BALANCE CENTER LINE AS SHOWN IN VIEW A-A.

4-END OF HAIR SPRING MUST NOT PROTRUDE BEYOND EDGE OF PLATE NO 1.



NEXT ASSY	USED ON
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.	
DR A. S. P.	SCALE 4:1
REVISION	DATE
A. A.S.P.	3/11/63
CH	
APPR	
DATE 9/12/62	
TITLE MOVEMENT ASSY, T5E1	NO. 8864297

HV-51



NOTES:

1- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY.

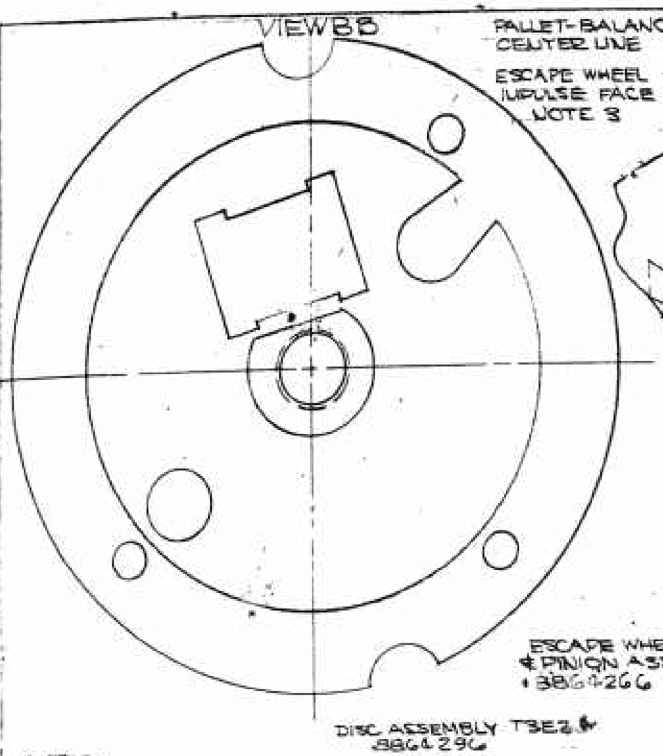
2-ADJUST BEAT RATE ON ANY STANDARD WATCH BEAT RATE RECORDER OR OTHER MEANS TO 50 ± .25 BEATS PER SECOND, BEAT RATE MUST BE HELD WITHIN THESE LIMITS FOR A MINIMUM OF ONE & ONE-HALF (1½) TURNS FROM FULL WIND OR 144 SECONDS.

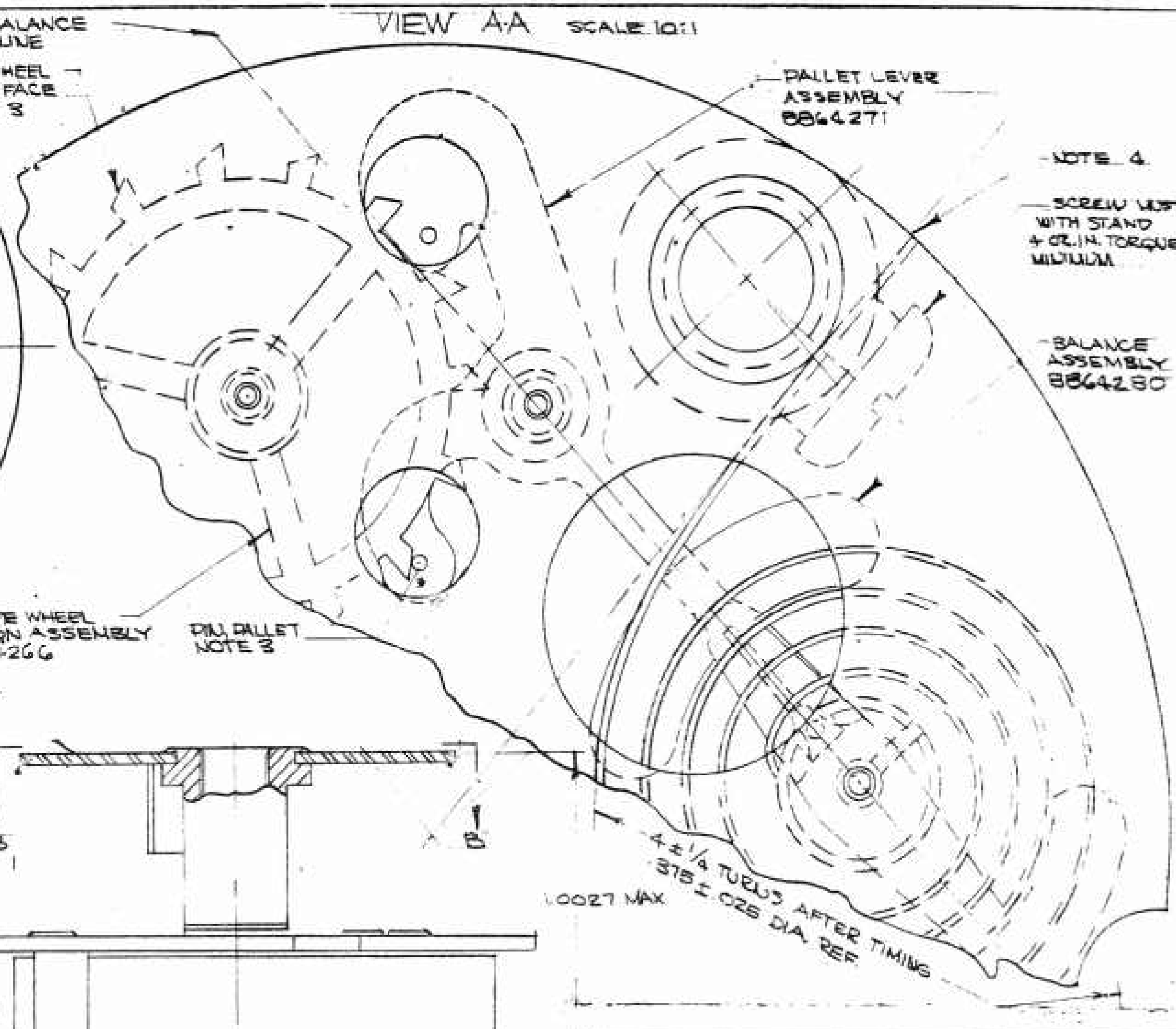
3-AFTER THE BEAT RATE HAS BEEN ADJUSTED, POSITION THE HAIRSPRING HUB SO THAT ONE PALLET PIN IS WITHIN THE LEAD HALF OF THE ESCAPE WHEEL TOOTH IMPULSE FACE WHEN THE SPOKE OF THE BALANCE ASSEMBLY IS HELD ON THE PALLET-BALANCE CENTERLINE AS SHOWN IN VIEW A-A.

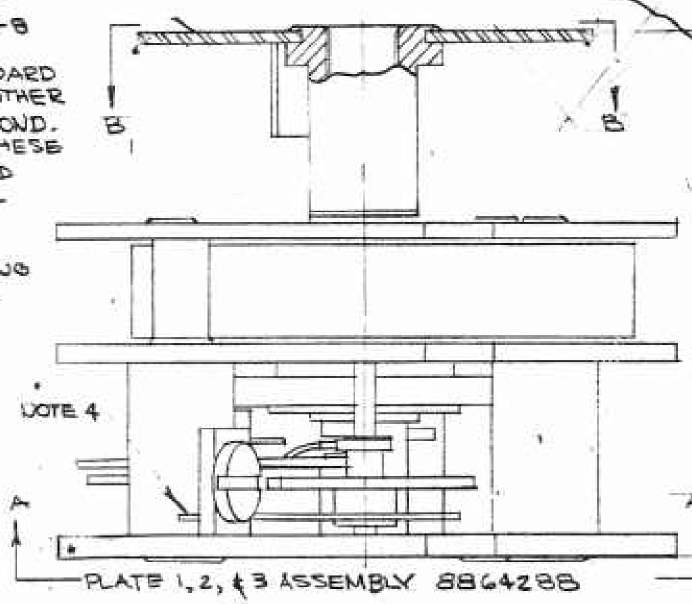
4-END OF HAIRSPRING MUST NOT PROTUDE BEYOND EDGE OF PLATE NO. 1.

NEXT ASSY	USED ON		
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR A. S. P.	SCALE 4:1	REVISION	DATE
CH.		A. ASP.	3/1/63
APPR.			
DATE 9/12/62			
TITLE MOVEMENT ASSY. T4E1		NO 8864298	

HY-52







NOTES:

- SPECIFICATION MIL-A-2550 & MIL-STD-8 APPLY
2- ADJUST BEAT RATE ON ANY STANDARD WATCH BEAT RATE RECORDER OR OTHER MEANS TO 50 ± .25 BEATS PER SECOND. BEAT RATE MUST BE HELD WITHIN THESE LIMITS FOR A MINIMUM OF ONE AND ONE-HALF (1½) TURNS FROM FULL WIND OR 144 SECONDS.
5- AFTER THE BEAT RATE HAS BEEN ADJUSTED, POSITION THE HAIRSPRING HUB SO THAT ONE PALLET PIN IS WITHIN THE LEAD HALF OF THE ESCAPE WHEEL TOOTH IMPULSE FACE WHEN THE SPOKE OF THE BALANCE ASSEMBLY IS HELD ON THE PALLET-BALANCE CENTERLINE AS SHOWN IN VIEW A-A.
4- END OF HAIRSPRING MUST NOT PROTRUDE BEYOND EDGE OF PLATE NO. 1.

NEXT ASSY	USED ON		
HAIRSPRING VIBRATING CO. DIV. OF TORQUE CONTROLS, INC. UNION CITY, N. J.			
DR. A.S.P.	SCALE 4:1	REVISION	DATE
CH.			
APPR			
DATE 9/12/62			
TITLE MOVEMENT ASS'Y, T3E2	8864299		

HV-53

SECTION IX

MILITARY SPECIFICATION DRAFT

1. Scope

1.1 Scope. This specification covers the parts for one type of mechanical timer movement assemblies designated as Movement Assembly, MT, 90 Seconds, T3E2, T4E1 and T5E1.

1.2 Description. This movement embodies a spring driven gear train and tuned escapement, capable of rotational mechanical output. The output shaft will make one revolution in 96 seconds.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids, form a part of this specification description to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-A-2550 - General Specification for Ammunition Except Small Arms Ammunition.

MIL-P-10025- Packaging, Packing and Marking for Interplant Shipment of Inert Ammunition Components.

MIL-Q-9858 - Quality Control System Requirement.

STANDARDS

MILITARY

MIL-STD-105- Sampling Procedures and Tables for Inspection by Attributes.

MIL-STD-109 - Inspection Terms and Definitions.

MIL-STD-643 - Evaluation of Contractor Quality Control System.

MIL-STD-350 - Jolt.

MIL-STD-351 - Jumble.

MIL-STD-353 - Transportation Vibration Test for Use in Production of Fuzes.

DRAWINGS

ORDNANCE CORPS

8864297 Movement Assembly, MT, 90 Seconds, T5E1

8864298 Movement Assembly, MT, 90 Seconds, T4E1

8864299 Movement Assembly, MT, 90 Seconds, T3E2

PUBLICATIONS

ORDNANCE CORPS

ORD-M608-11 - Procedures and Tables for Continuous Sampling by Attributes.

IEL - Index of Inspection Equipment Lists

(Copies of specifications, standards, drawings and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer).

3. REQUIREMENTS

3.1 Material - Materials and parts shall be in accordance with applicable drawings and specifications.

3.2 <u>Movement Assemblies</u> - The movement assemblies shall comply with all requirements specified on the applicable assembly drawing (Drawing 8864297, 8864298, 8864299) and with all requirements specified in applicable specifications.

3.3 <u>Beat rate and self-starting reliability</u> - The movement assembly shall be self-starting and have a beat rate of 50 $\pm$ .25 beats per second when tested as specified in 4.4.1.

3.4 <u>Torque output</u> - The torque output during the initial 360 degrees rotation shall not be less than 9 ounce inches, and beat rate requirement specified in 3.3 is maintained, when tested as specified in 4.4.2.

3.5 <u>Starting and operating torque</u> - The maximum torque, measured at the output shaft, required to start the escapement shall not exceed eight ounce inches. The maximum torque, measured at the output shaft, required to sustain operation shall not exceed four ounce inches. These shall be tested as specified in 4.4.3.

3.6 <u>Gear train proof load</u> - There shall be no evidence of slippage, distortion or fracture in the gear train when tested as specified in 4.4.4.

3.7 <u>Transportation Vibration</u> - The movement assemblies shall withstand the transportation vibration test specified in MIL-STD-353 when tested as specified in 4.4.5.

3.8 <u>Functioning</u> - The movement assemblies shall be self-starting and provide 360 degree rotation of the timing disc in 96 seconds $\pm$ 0.5 seconds when tested as specified in 4.4.6.

3.9 <u>Jolt</u> - The movement assemblies shall withstand the jolt test specified in MIL-STD-350 when tested as specified in 4.4.9.

3.10 <u>Jumble</u> - The movement assemblies shall withstand the jumble test specified in MIL-STD-351 when tested as specified in 4.4.9.

3.11 <u>Workmanship</u> - All parts shall be free of chips, dirt, grease, rust and other foreign materials. Particular attention shall be given to freedom of the parts from burrs and sharp edges. The cleaning method shall not be injurious to any of the parts nor shall the parts be contaminated by the cleaning agent.

4. QUALITY ASSURANCE PROVISIONS

4.1 <u>General quality assurance provisions</u> - The supplier is responsible for the performance of all inspection requirements specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examinations and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements. Reference shall be made to MIL-STD-109 in order to define the terms used herein. Inspection shall be performed in accordance with this specification and other specifications referenced in any of the contractual documents.

4.1.1 Contractor quality assurance system - The contractor shall provide and maintain an effective quality assurance system acceptable to the Government covering the supplies procured under this specification and shall perform all inspections required by the system. A current written description of the system shall be submitted to the contracting officer, and meet his approval, prior to initiation of production. It shall include a description covering controls for lot formation and identification, inspections to be performed, inspection stations, sampling procedures, methods of inspection (gages, measuring and testing equipment), and provisions for the control and disposition of non-conforming material. The written description will be considered acceptable when, as a minimum, it provides the quality assurance required by the provisions of 4.3.2 and 4.3.3 and the other documents referenced herein. The contractor shall not be restricted to the inspection station nor the method of inspection listed in this specification provided that an equivalent control is included in the approved quality assurance procedure. In cases of dispute as to whether certain procedures of the contractor's system provide equal assurance, the comparable procedure of this specification shall apply. The contractor shall notify the Government of, and obtain approval for, any change to the written procedure that effects the degree of assurance required by this specification or other documents referenced herein.

4.1.2 <u>Submission of product</u> - At the time the completed lot of product is submitted to the Government for acceptance the contractor shall supply the following information accompanied by a certificate which attests that the information provided is correct and applicable to the product being submitted:

a. A statement that the lot complies with all quality assurance provisions of the approved current written description of the system.

b. Number of units of product inspected.

c. Results obtained for all inspections performed.

d. Drawing, specification number and date, together with an identification and date of changes.

e. Certificates of analysis on all material procured directly by the contractor.

f. Number of items in the lot.

g. Date submitted.

The certificate shall be signed by a responsible agent of the certifying organization. The initial certificate submitted shall be substantiated by evidence of the agent's authority to bind his principal. Substantiation of the agent's authority will not be required with subsequent certificates unless, during the course of the contract, this authority is vested in another agent of the certifying organization.

4.1.3 Government verification - Using the contractor's written quality assurance procedure, this detail specification, the applicable drawings and other contractual documents as a guide, the Government inspector shall verify at unscheduled intervals all quality assurance operations performed by the contractor. Verification shall consist of: (a) surveillance of contractor operations to determine that the methods and procedures of the written procedure are being properly applied and (b) Government product inspection. The Government inspector shall also ascertain prior to acceptance that the product complies with all the quality assurance provisions of other specifications referenced in any of the contractual documents.

4.1.3.1 Surveillance - Surveillance shall include, but is not limited to:

a. Observation of procedures concerning lot formation and identification.

b. Observation of sampling procedures and application of acceptance criteria.

c. Determination that all required examinations and tests are performed in accordance with the prescribed procedures of this specification, or approved equivalents thereto.

d. Review of procedures for control and disposition of nonconforming material.

4.1.3.2 Product inspection - Physical inspection by the Government of contractor accepted product will be performed to the extent necessary to assure contractor compliance with the requirements of this specification and to determine the reliability of contractor records. Severity of Government inspection of individual characteristics will be directly related to the seriousness of the classification assigned. In no instance will a characteristic classified "critical" be accepted solely on the basis of the contractor's records, Specification MIL-A-2550 will apply.

4.1.3.3 Deviations and deficiencies - Deviations from the prescribed or agreed upon procedures, or instances of poor practice which might have an effect on the quality of the product, shall be called to the attention of the contractor immediately. To avoid interference with operation, the contractor shall designate a responsible official, or officials, to whom the Government inspector will report such instances. Failure of the contractor to correct deficiencies promptly shall be cause for suspension of acceptance until correction has been made or until conformance to prescribed criteria has been demonstrated.

4.1.3.4 Inspection records - Unless otherwise specified, the contractor shall be responsible for the performance of all inspection requirements prior to submission for government inspection and acceptance. Test records shall be kept complete and available to the government for the duration of the contract. In addition, the contractor shall submit all test results as specified in 6.3, the format for which shall be in accordance with Appendix A, Master Control Sheets. The contractor shall not be responsible for records of inspections conducted by the government (see 6.3).

4.2 Pilot lot - The contractor shall submit a pilot lot of 25 each parts and sub-assemblies and 35 complete assemblies, which have been produced by the production process which the contractor will use in fulfilling the contract, to a Government-approved facility designated by the contracting officer. Production prior to pilot lot approval will be at the risk of the contractor. The pilot lot shall be approved by the Government prior to initiation of production. Resubmission of pilot lot shall be at the contractor's expense (see 6.1).

4.2.2 Inspections to be performed - Each component part, sub-assembly and assembly shall be inspected for compliance with all applicable requirements of the drawings, specifications, and tests specified in section 4.4 of this specification draft. In addition, the following special tests shall be performed.

4.2.2.1 Jolt and jumble (see 3.9 and 3.10) - Twelve of the completely assembled movement assemblies shall be mounted as specified in 4.4.9 and subjected to the test specified in MIL-STD-350, except that after the test the assemblies shall not be examined but shall be subjected to the tests specified in MIL-STD-351. A movement shall be rejected only if one of the following occurs: a) The timing disc disassembles from the movement nut; b) Any plate disassembles from the posts.

4.2.3 Rejection - If any component fails to comply with the applicable requirements, the preproduction quantity shall be rejected and the contractor shall take the necessary corrective action and submit a new preproduction quantity, or portion thereof, as specified by the contracting officer. The contractor shall continue to submit new or supplemental quantities as necessary, until such time as a quantity successfully passes the inspections specified or until otherwise directed by the procuring activity.

4.3 Inspection Provisions.

4.3.1 Lot formation - A lot shall consist of movement assemblies produced by one manufacturer in one unchanged process, in accordance with the same drawing, same drawing revision, same specification and same specification revision. Drawing, specification and process changes not affecting safety, performance, or fit, as determined by the Government, shall not necessitate changing the lot number.

4.3.2 Examination - Sampling plans and procedures for the following classifications of defects shall be in accordance with MIL-STD-105 except that inspection for critical defects, when listed, shall be 100 percent. Continuous sampling plans in accordance with Handbook ORD-M608-11 may be used if approved by the procuring activity. Also, at the option of the procuring activity, AQL's and sampling plans may be applied to the individual characteristics listed using an AQL of 0.25 percent for each major defect and an AQL of 0.40 percent for each minor defect. Equipment necessary for the performance of the inspections listed shall be in accordance with 4.3.4.

4.3.2.1 Plates No. 1, 2 & 3 (see dwgs. 8864251, 8864281 & 8864287 covering a detail of dwgs. 8864297, 8864298 & 8864299).

Categories	Defects	Method of inspection
Critical:	None defined.	
Major:	AQL 0.65 percent	
	101. Plate OD max	Gage
	102. Any hole improperly positioned	Gage
	103. Hole size min	Gage
	104. Burrs around holes	Visual
	105. Plate flatness max	Gage
	106. Evidence of poor workmanship (see 3.11)	Visual

4.3.2.2. Plate No. 1 and Post Assembly (see dwg. 8864254 covering a detail of dwgs. 8864297, 8864298 and 8864299).

Categories	Defects	Method of Inspection
Critical: None defined		
Major:	AQL 0.25 percent	
101.	Height of stake max	Gage
102.	Evidence of poor workmanship (see 3.11)	Visual

4.3.2.3 Balance and Shaft Assembly (see dwg. 8864276 covering a detail of dwgs 8864297, 8864298 and 8864299).

Categories	Defects	Method of Inspection
Critical: None defined		
Major:	AQL 0.25 percent	
101.	Impulse pin not aligned with safety roller relief	Gage
102.	Evidence of poor workmanship (see 3.11)	Visual

4.3.2.4. Balance Assembly (see dwg. 8864280 covering a detail of dwgs. 8864297, 8864298 and 8864299).

Categories	Defects	Method of Inspection
Major:	AQL 0.40 percent	
101.	Hairspring not perpendicular to balance shaft	Visual
102.	Hairspring not tight	Visual-Manual
103.	Pivots not cylindrical	Visual
104.	Evidence of poor workmanship (see 3.11)	Visual

4.3.2.5 Pallet & Pin Assembly (see dwg. 8864269 covering a detail of dwgs. 8864297, 8864298 & 8864299).

Categories	Defects	Method of Inspection

Critical: None defined.

Major: AQL 0.25 percent

101. Pallet guard not parallel to pallet lever..Gage
102. Evidence of poor workmanship (see 3.11)....Visual

4.3.2.6 Pallet lever Assembly (see dwg. 8864271 covering a detail of dwgs. 8864297, 8864298 & 8864299).

Categories	Defects	Method of Inspection

Critical: None defined.

Major: AQL 0.40 percent

101. Pallet pins scored or damaged..............Visual
102. Pivots not cylindrical....................Visual
103. Evidence of poor workmanship (see 3.11)....Visual

4.3.2.7 Escapewheel assembly (see dwg. 8864266 covering a detail of dwgs. 8864297, 8864298 & 8864299).

Categories	Defects	Method of Inspection

Critical: None defined.

Major: AQL 0.65 percent

101. Concentricity of escapewheel to pinion.....Gage
102. Escapewheel not perpendicular to pinion....Gage
103. Improper escapewheel teeth finish...Gage-Visual Aid
104. Tooth missing or damaged...................Visual
105. Pivots not cylindrical....................Visual
106. Evidence of poor workmanship (see 3.11)....Visual

4.3.2.8 Gear No. 2 and Pinion No. 2 Assembly (see dwg. 8864263 covering a detail of dwgs. 8864297, 8864298 & 8864299).

Categories	Defects	Method of Inspection

Critical: None defined.

Major: AQL 0.65 percent

101. Concentricity of gear to pinion............Gage
102. Perpendicularity of gear to pinion.........Gage
103. Burrs on gear teeth...............Visual-Manual
104. Tooth missing or damaged..................Visual
105. Pivots not cylindrical....................Visual
106. Evidence of poor workmanship (see 3.11)....Visual

4.3.2.9 Gear No. 1 and Pinion No. 1 Assembly (see dwg. 8864261 covering a detail of dwgs. 8864297, 8864298 & 8864299).

Categories	Defects	Method of Inspection

Critical: None defined.

Major: AQL 0.65 percent

101. Concentricity of gear to pinion............Gage
102. Perpendicularity of gear to pinion.........Gage
103. Burrs on gear teeth...............Visual-Manual
104. Tooth missing or damaged..................Visual
105. Pivots not cylindrical....................Visual
106. Evidence of poor workmanship (see 3.11)....Visual

4.3.2.10 Arbor, Center (see dwg. 8864257 covering a detail of dwgs. 8864297, 8864298 & 8864299).

Categories	Defects	Method of inspection
Critical:	None defined.	
Major:	AQL 0.40 percent	
	101. Length of thread min.	Gage
	102. Height of hook min.	Gage
	103. Pivots burred or not cylindrical.	Visual
	104. Evidence of poor workmanship (see 3.11).	Visual

4.3.2.11 Arbor & Center Gear Assembly (see dwg. 8864258 covering a detail of dwgs. 8864297, 8864298 & 8864299).

Categories	Defects	Method of inspection
Critical:	None defined.	
Major:	AQL 1.00 percent	
	101. Concentricity of gear to arbor.	Gage
	102. Perpendicularity of gear to arbor.	Gage
	103. Burrs on teeth.	Visual
	104. Tooth width min.	Gage
	105. Tooth missing or damaged.	Visual
	106. Gear not free.	Visual-Manual
	107. Evidence of poor workmanship (see 3.11).	Visual

4.3.2.12 <u>Plate No. 1 & 2 Assembly (see dwg. 8864284 covering a detail of dwgs. 8864297, 8864298 & 8864299</u>).

<u>Categories</u>	<u>Defects</u>	<u>Method of inspection</u>
Critical:	None defined.	
Major:	AQL 0.65 percent	
	101. Plate improperly assembled	Visual-Manual
	102. Arbor jammed	Visual-Manual
	103. Improper pallet pin & escapewheel root clearance	Visual-Manual
	104. Clearance between impulse pin and pallet guard min	Visual-Manual
	105. Pallet guard and safety roller engagement min	Visual-Manual
	106. Any operation missing or incomplete	Visual-Manual
	107. Evidence of poor workmanship (see 3.11)	Visual

4.3.2.13 T3E2, T4E1 & T5E1 Movement Assemblies (see dwgs. 8864297, 8864298 & 8864299).

Categories	Defects	Method of inspection
Critical:	None defined.	
Major:	AQL 0.65 percent	
	101. Any shaft pivot not free...........	Visual-Manual
	102. Pallet pin not oriented to ℄ balance-pallet....................................	Visual
	103. Hairspring lock screw not secure..........	Gage
	104. Any component or operation missing........	Visual
	105. Evidence of poor workmanship (see 3.11)...	Visual
Minor:	AQL 1.50 percent	
	201. Hairspring not level......................	Visual
	202. Interrupted spiraling of coils when balance is in motion...............	Visual-Manual
	203. Hairspring OD clashes against Hairspring lock or center arbor extension when movement is operating.....................	Visual

4.3.3 Testing

4.3.3.1 Beat rate and self-starting reliability (see 3.3)-Major defect - This test shall be conducted 100 percent. Any movement assembly which fails to comply with the applicable requirement shall be classed defective and removed from the lot. The test shall be conducted as specified in 4.4.1 using test equipment in accordance with 4.3.4.

4.3.3.2 Torque output (see 3.4)- Major defect - The sampling plans for this test shall be in accordance with MIL-STD-105 using code letter J and AQL of 0.65 percent. The test shall be conducted as specified in 4.4.2 using test equipment in accordance with 4.3.4. Any assembly which fails to comply with the specified requirement shall be classed defective.

4.3.3.3 Starting and operating torque (see 3.5)-Major defect - The sampling plans for this test shall be in accordance with MIL-STD-105 using code letter K and an AQL of 0.40 percent. The test shall be conducted as specified in 4.4.3 using test equipment in accordance with 4.3.4. Any assembly which fails to comply with the specified requirement shall be classed defective.

4.3.3.4 Gear train proof load (see 3.6)- Major defect - The sampling plans for this test shall be in accordance with MIL-STD-105 using code letter J and an AQL of 0.40 percent. The test shall be conducted as specified in 4.4.4 using test equipment in accordance with 4.3.4. Any assembly which fails to comply with the specified requirement shall be classified defective.

4.3.3.5 Transportation vibration (see 3.7) - Major defect - The sampling plans for this test shall be in accordance with MIL-STD-105 using code letter K and an AQL of 0.40 percent. The test shall be conducted as specified in 4.4.5 using equipment in accordance with 4.3.4. Any assembly which fails to comply with the specified requirements shall be classified defective.

4.3.3.6 Functioning (see 3.8) - Major defect - The sampling plans for this test shall be in accordance with MIL-STD-105 using code letter J and an AQL of 0.65 percent. The test shall be conducted as specified in 4.4.6 using test equipment in accordance with 4.3.4. Any assembly which fails to comply with the specified requirements shall be classified defective.

4.3.3.7 Pull and torque test of pinion and gear assemblies, escapewheel and pinion assembly, pallet lever assembly & balance and shaft assembly (see dwgs. 8864261, 8864263, 8864266, 8864271 & 8864276) - Major defect - The sampling plans for this test, applied separately to each assembly, shall be in accordance with MIL-STD-105 using code letter K and AQL of 0.65 percent. The test shall be performed as specified in 4.4.7 using equipment in accordance with 4.3.4. Any assembly which fails to comply with the specified requirements shall be classified defective.

4.3.3.8 Pull test of plate assemblies, disc assemblies, arbor and center gear assembly, pallet and pin assembly, balance and impulse pin assembly (see Drawings 8864254, 8864258, 8864269, 8864274, 8864282, 8864288, 8864291, 8864293 & 8864296) - Major defect - The sampling plans for this test, applied separately to each assembly, shall be in accordance with Standard MIL-STD-105 using code letter K and an AQL of 0.65 percent. The test shall be performed as specified in 4.4.8 using equipment in accordance with 4.3.4. Any assembly which fails to comply with the specified requirement shall be classified defective.

4.3.3.9 Mainspring Torque (see Drawing 8864285) - Major defect - The sampling plans for this test shall be in accordance with MIL-STD-105 code letter J and an AQL of 0.65 percent. Test shall be conducted as specified in 4.4.10 using test equipment in accordance with 4.3.4. Any assembly which fails to comply with the specified requirements shall be classified defective.

4.3.3.10 Balance assembly torque test (see Drawing 8864280) - Major defect - The sampling plans for this test shall be in accordance with MIL-STD-105 code letter J and and AQL of 0.65 percent. Test shall be conducted as specified in 4.4.11 using test equipment in accordance with 4.3.4. Any assembly which fails to comply with the specified requirements shall be classified defective.

4.3.4 Inspection eq. .pment - For the performance of the examinations and tests specified in 4.3.2 and 4.3.3, when applicable, the contractor shall have available, and utilize correctly, all necessary gages, measuring and testing equipment identified by Index of Inspection Equipment No.   or approved equivalents thereto. When inspecting the contractor's inspection equipment, the Government inspector will determine that the contractor has available, and utilizes correctly, gages, measuring and testing equipment of the required accuracy and precision and that the instruments are of the proper type and range to make measurements of the required accuracy. The contractor will have available a set of master gages, standards, and appropriate instruments for regularly scheduled calibration of his inspection equipment. Records of such regularly scheduled calibration will be maintained by the contractor and made available for review by the Government. The calibration of gages, standards, and instruments will be periodically checked by authorized Government personnel.

4.3.4.1 Government use and surveillance of inspection equipment - Government verification inspection, as described in 4.3.2, will be accomplished with the use of gages and equipment, of approved design, that has been certified by the Contracting Officer, to the design approved by the procuring activity. In inspecting the contractor's approved and certified inspection equipment, the Government inspector will determine that the contractor has available and continues to utilize correctly, gaging, measuring and test equipment of required accuracy and that the instruments are of proper types and range to make measurements of the required accuracy.

4.4 Test methods and procedures

4.4.1 Beat rate and self-starting reliability - The movement assembly shall be mounted on an audio pickup of an approved beat rate recorder with the timing disc restrained within one turn from full wound by a flat end pin inserted into the timing disc slot. The pin shall be withdrawn from the timing disc and the beat rate recorded for 20" minimum.

4.4.2 Torque output - The movement assembly shall be fully wound, securely mounted on an audio pickup of an approved beat rate recorder and allowed to start. Apply an opposing minimum torque of 9 ounce inches to the timing disc in a clockwise direction immediately after starting and after 360 degree rotation of the output shaft.

4.4.3 Starting and operating torque - A plate No. 1 and 2 assembly (see Drawing 8864282) shall have the hair-spring and lock secured such that either pallet pin is positioned within the lead half of the escapewheel impulse face. A Plate No. 3 shall be press fit on to the three pillar posts and a two inch diameter pulley shall be securely fastened to the output shaft. A means of locking the pulley must be provided. This assembly shall be securely mounted on a suitable fixture in a vertical position as shown in 8864282 Section A-A. Tie a string to the pulley and attach a four ounce dish containing a four ounce weight to the free end. With torque thus applied, allow movement to run until the pulley is stopped by the locking pin. After the balance is visually motionless, the movement must self-start with the sharp removal of the locking pin. Remove the four ounce weight leaving only the four ounce dish. Movement must continue to run.

4.4.4. Gear train proof load - The assemblies used in this test shall have successfully passed the starting and operating torque test specified in 4.4.3. The assembly shall be securely mounted on a suitable fixture with the balance restrained from oscillating. Apply a minimum torque of 35 ounce inches to the output shaft in a counterclockwise direction and examine the gear train.

4.4.5 Transportation vibration - The movement assemblies, half the samples full wound and the other half unwound, shall be assembled to holding fixtures which restrain the timing disc from rotating and subjected to this test in accordance with Standard MIL-STD-353, Sections 4, 5 (less 5.6), 6 and 7.

4.4.6 Functioning - The movement assemblies to be used in this test shall have successfully passed the transportation vibration test specified in 4.4.5. The sample movement assemblies shall be divided into 2 groups of equal size containing an equal number of movements which were vibrated full wound. The movement assemblies shall be fully wound, mounted in a fixture and the movement allowed to start. The movement shall be stopped by restraining the timing disc when the disc has rotated a minimum of ¼ turn. The movement assemblies shall then be conditioned for a period not less than one hour as follows:

Group	Temperature
Group No. 1	$-65 \pm 5°F$
Group No. 2	$+165 \pm 5°F$

The fixture used for Group No. 1 shall be completely closed and contain a dessicant to eliminate frost formation on the gear train. The movement assemblies shall be allowed to start and the time required for one complete rotation of the disc recorded.

4.4.7 <u>Pull and torque tests of pinion and gear assemblies, escapewheel and pinion assembly, pallet lever assembly & balance and shaft assembly</u> - These tests shall be performed as specified on the applicable drawing. Each sample shall first be subjected to the pull test and then the torque tests. Examination shall be made to determine any evidence of loosening, separation or slippage.

4.4.8 <u>Pull test of plate assemblies, disc assemblies, pallet and pin assembly, arbor and center gear assembly & balance and impulse pin assembly</u> - This test shall be performed as specified on the applicable drawing.

Examination shall be made to determine any evidence of loosening or separation.

4.4.9 Jolt and jumble - The movement assemblies shall be fully wound, mounted in a suitable supporting fixture with the timing disc restrained from rotating, and tested in accordance with the procedures specified in Standards MIL-STD-350 and 351, Sections 4,5, 6, 7 and 8, except that after completion of the jolt test, the movement assemblies shall not be examined but shall be subjected to the jumble test and then examined to determine compliance with the requirements specified in 4.2.2.1.

CAUTION: The tests specified in 4.4.6, 4.4.7, 4.4.8 and 4.4.9 are considered destructive. Assemblies used for these tests shall be kept separate from other production and be positively identified.

4.4.10 Mainspring Torque - The mainspring shall be mounted on the test equipment specified in 4.3.4. The mainspring shall be fully wound and allowed to unwind ½ turn. Turn Torquemeter in a clockwise direction until index screw is released from ratchet stop, note reading. Allow mainspring to unwind an additional 1½ turns, release index screw from ratchet stop and note reading.

4.4.11 Torque test of balance assembly - This test shall be performed as specified on the applicable drawing. Examination shall be made to determine any evidence of slippage.

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5. PREPARATION FOR DELIVERY

5.1 Packing - Packing shall conform to Specification MIL-P-10025.

5.2 Marking - Marking shall conform to Specification MIL-P-10025.

5.3 Data cards - Data card information shall be as specified in Specification MIL-A-2550.

6. NOTES

6.1 Ordering data - Procurement documents should specify the following:

a. Title, number and data of this specification.

b. The approving agency for the pilot lot.

6.2 Test equipment - This will be covered in the index of inspection equipment lists.

6.3 Inspection provisions - Alternative inspection procedures and inspection equipment may be used by the contractor when such procedures and equipment provide, as a minimum, quality assurance required in the contractual documents. The contractor shall demonstrate for government approval that such alternate methods are equal to or better than the required procedures prior to production. The inspection procedures and equipment specified will prevail in case of dispute.

6.4 Inspector's log - The government inspector shall maintain a log in which are recorded the times of his monitoring visits, the operations surveyed, deficiencies or improvements in procedures noted, and the action taken by him or the contractor as a result of such visits.

6.5 Submission of test data - In addition to normal distribution of records, when item is procured under the jurisdiction of the Department of the Army, copies will be forwarded to the following:

2 copies - Ordnance Ammunition Command
Joliet, Illinois; ATTN: ORDLY-AIR

1 copy - Picatinny Arsenal
Dover, New Jersey; ATTN: ORDBB-DC3

6.6. Intended use - The inert parts described herein are designed for use in mechanical time bomb fuzes.

6.7 Change in process - The process includes all inspection operations such as screening, sampling or otherwise, which are conducted by the contractor. A change in any contractor inspection operation and screening, and sampling is construed as a change in process.

6.8 Dimensions and tolerances - Dimensions and tolerances specified represent a design objective for the manufacture of this timer. Compliance is mandatory and must be certified to on the attached sample certification form.

6.9 Documents

6.9.1 Procurement - Publication PA-OAP-1, Production Verification Inspection Plan may be ordered from Picatinny Arsenal, Dover, New Jersey, ATTN: ORDBB-D.

6.9.2 Use - The use of Publication PA-QAP-1, is mandatory only upon the Government inspector and shall not be used by the contractor for any purpose other than informational.

Notice. When Government drawings, specifications or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodian:	Preparing activity:
Army-Ordnance Corps.	Army-Ordnance Corps.

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APPENDIX A

MASTER CONTROL SHEET

FOR

T3E2, T4E1 & T5E1 MOVEMENT ASSEMBLIES

LOT NO. ____________________

SERIAL NO. ________________

DRAWING NO. ___________ REV. ___________

MOVEMENT ____________________

REF: MIL-

1. INSPECTION

1.1 The movement assembly satisfactorily meets the requirements of paragraph 4.3.2 of MIL-

______________________( )

2. BEAT RATE & SELF-STARTING RELIABILITY

2.1 The movement assembly satisfactorily meets the requirements of paragraph 4.3.3.1 of MIL-

______________________( )

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3. TORQUE - MAINSPRING

Rundown in turns from full wound	Actual Reading Oz. In.	Required Torque Oz. In.
½		18 ± 2
1½		min.

3.1 The movement assembly satisfactorily meets the requirements of Dwg. 8864285 of MIL-

____________________( )

4. TORQUE - ESCAPEMENT STARTING AND OPERATING

Torque - escapement	Actual Reading Oz. In.	Required Torque Oz. In.
starting		8 max.
sustained		4 max.

4.1 The movement assembly satisfactorily meets the requirements of paragraph 4.3.3.3 of MIL-

____________________( )

5. GEAR TRAIN - PROOF LOAD

Torque	Actual Reading Oz. In.	Required Torque Oz. In.
Applied		35 min.

5.1 The movement assembly satisfactorily meets the requirements of paragraph 4.3.3.4 of MIL-

____________________( )

6. ESCAPEMENT ALIGNMENT

6.1 The movement assembly satisfactorily conforms to Note 3 on Dwgs. 8864297, 8864298 and 8864299.

____________________( )

7. FUNCTIONING

7.1 The movement assembly meets the functioning requirements of paragraph 4.3.3.6 of MIL-

____________________( )

8. PULL AND TORQUE TESTS

8.1 Movement assemblies and all sub-assemblies satisfactorily meet the requirements of paragraphs 4.3.3.7 and 4.3.3.8 of MIL-

____________________( )

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LIST ALL WAIVERS AND DCR'S

Inspection in accordance with prescribed specification and procedures and found satisfactory and acceptable.

Inspected in accordance with prescribed procedures and specifications and accepted.

Date	Contractor's Inspector	Date	Authorized Government Inspector
________	________________	________	________________

Manufactured by ____________________

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CERTIFICATE OF CONFORMANCE

TO: Picatinny Arsenal

(1) Date of Shipment ____________

(2) Contract No. ________________

(3) Quantity ____________________

(4) Part/Dwg.No. __________Rev.__

INSTRUCTIONS FOR FILLING OUT THIS FORM

IMPORTANT: Three (3) copies of the Certificate of Conformance are to be sent to Picatinny Arsenal with each shipment.

(1) Date of Shipment.
(2) Contract No.
(3) Quantity of items shipped.
(4) Part or drawing number and revision if any.
(5) Description of part or assembly.
(6) Type of material with specifications noted where applicable.
(7) Type of heat treating performed with specifications noted where applicable.
(8) Type of finish process with specifications noted where applicable.
(9) Type of test process performed with specifications noted where applicable.
(10) Inspector's signature.
(11) Supplier - Company name.
(12) Authorized representative.
(13) Title of authorized representative.

"I certify that the item, assembly, subassembly or part for which this report was made has been inspected and/or tested in compliance with a Government approved contractor procedure and that the results of the inspection and/or test are as shown.

____________________ ____________________________

(Date) (10) Inspector's signature

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We hereby certify that the above material and/or work performed by us is in accordance with all applicable specifications, drawings and/or other contract requirements. Test and/or inspection reports indicating conformance are on file with us or our suppliers for your examination.

(11) Supplier	(12) Authorized Signature	(13) Title

SECTION X

INSPECTION EQUIPMENT CONCEPT SKETCHES

Beat Rate & Self-Starting Reliability - Para 4.4.1

Torque Output - Para 4.4.2

Starting & Operating Torque - Para 4.4.3

Gear Train Proof Load - Para 4.4.4

Transportation Vibration - Para 4.4.5

Functioning - Para 4.4.6

Torque Test - Para 4.4.7

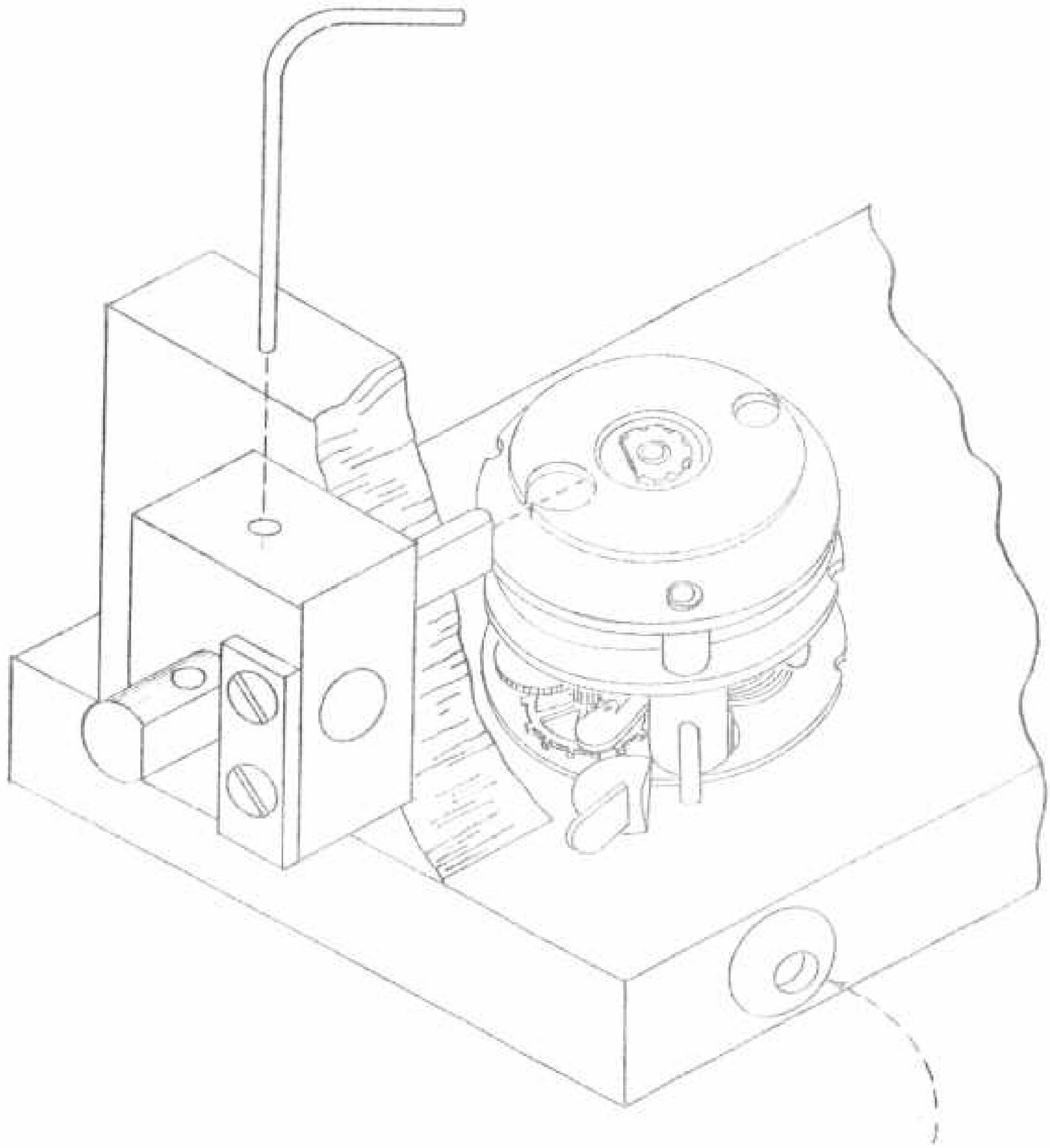
Load & Pull Test - Para 4.4.8

Jolt & Jumble - Para 4.4.9

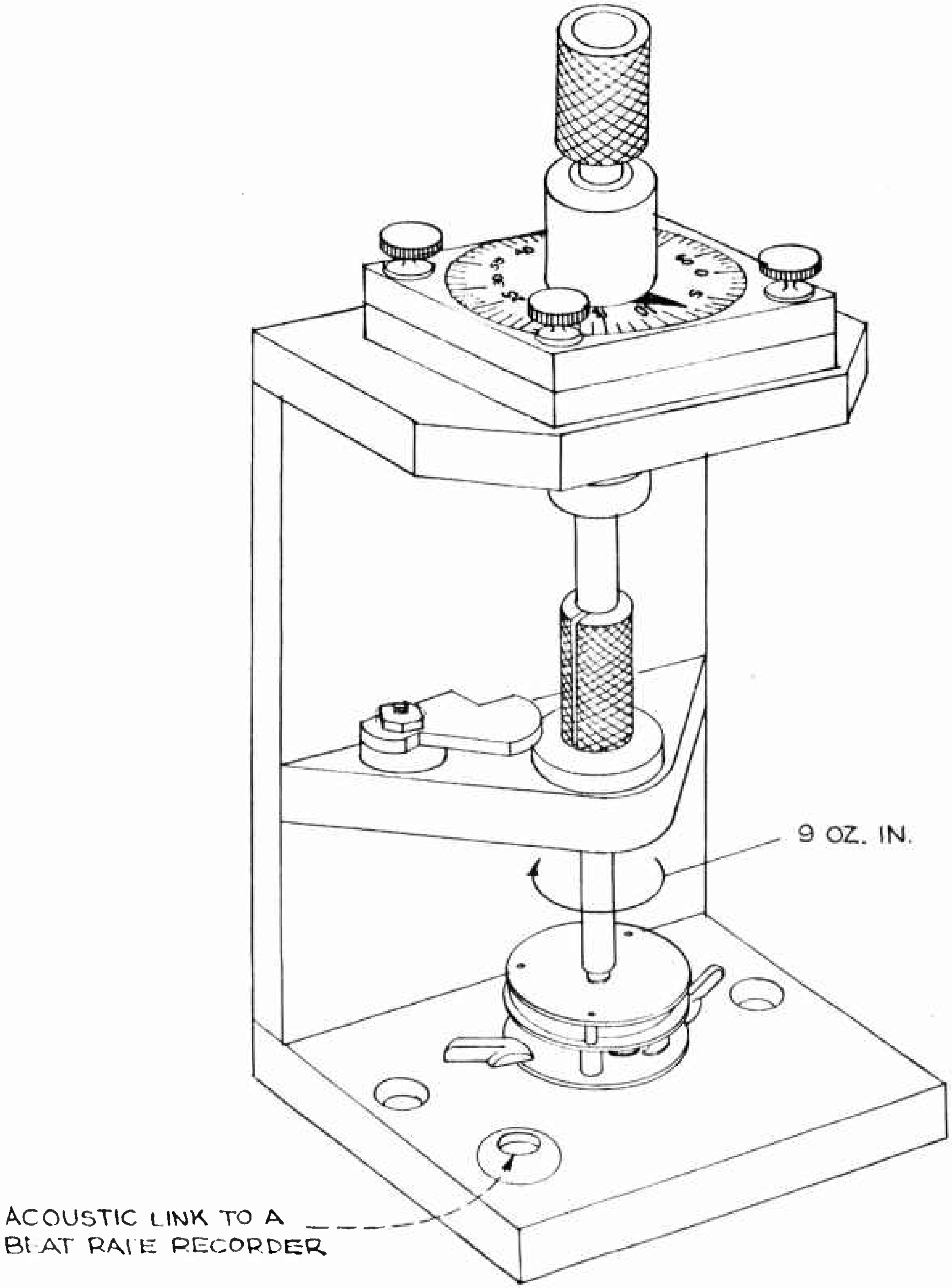
Mainspring Torque - Para 4.4.10

Standard Equipment For Load, Pull & Torque Tests

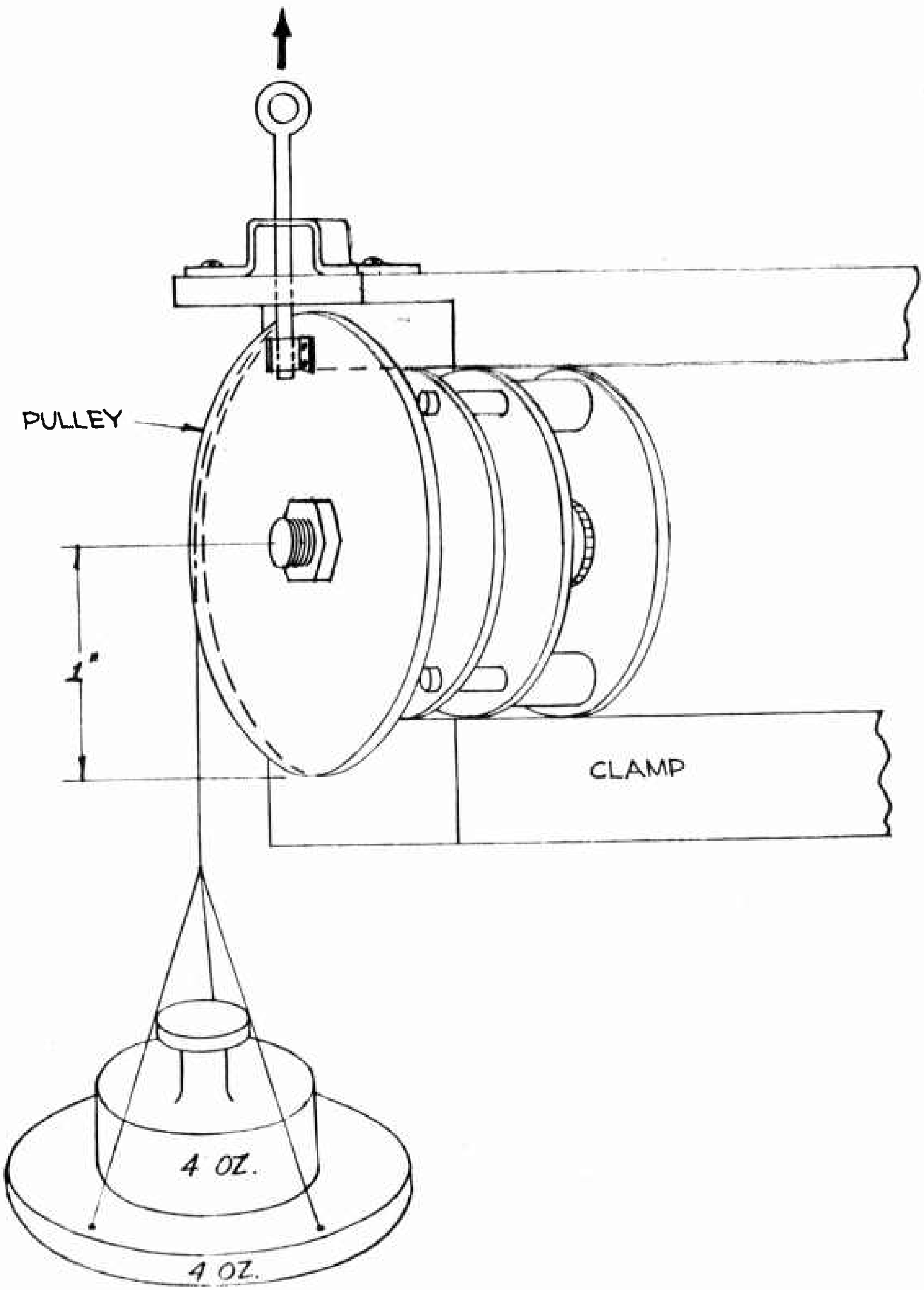
BEAT RATE AND SELF-STARTING RELIABILITY - Para 4.4.1



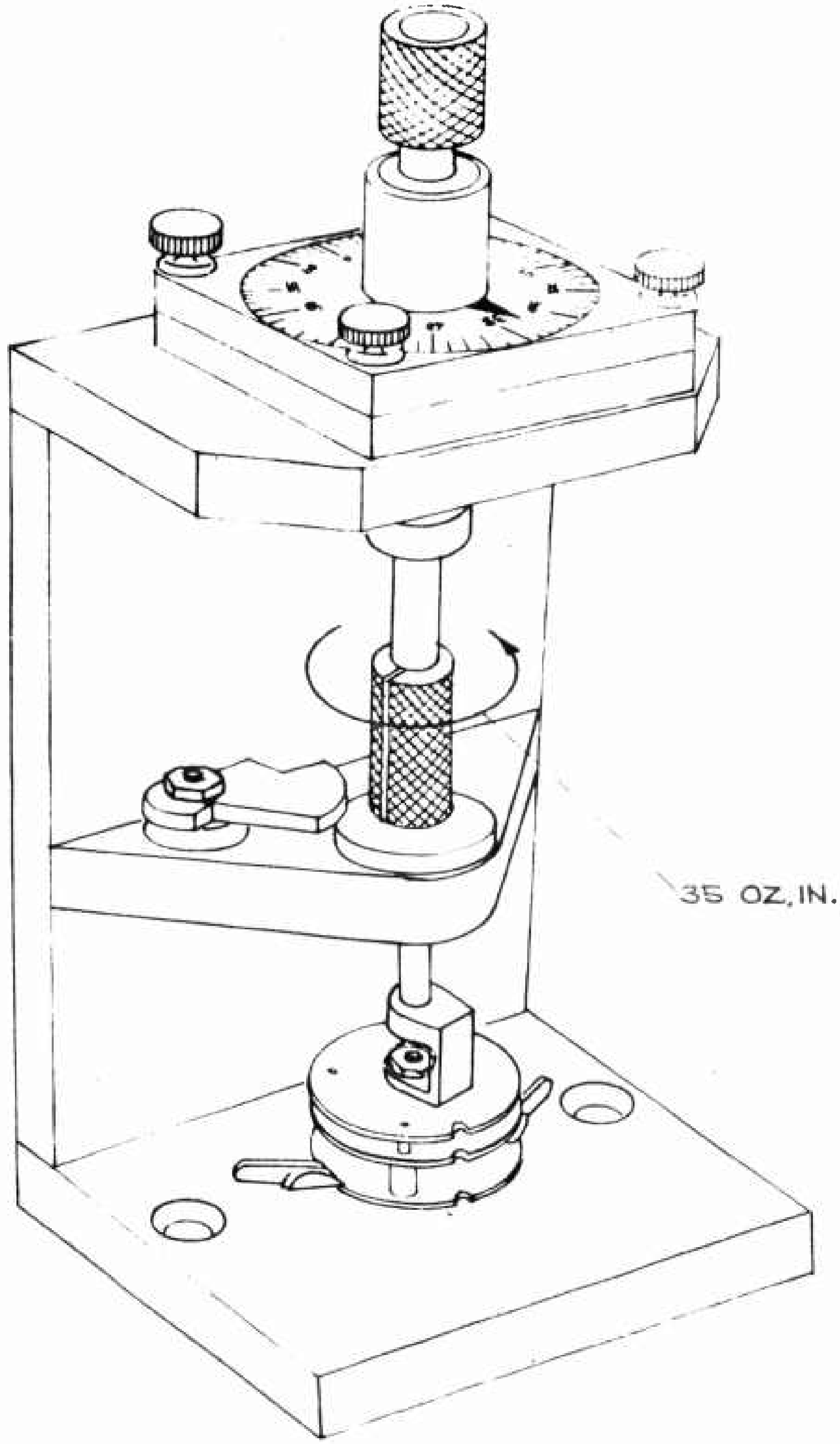
TORQUE OUTPUT - Para 4.4.2



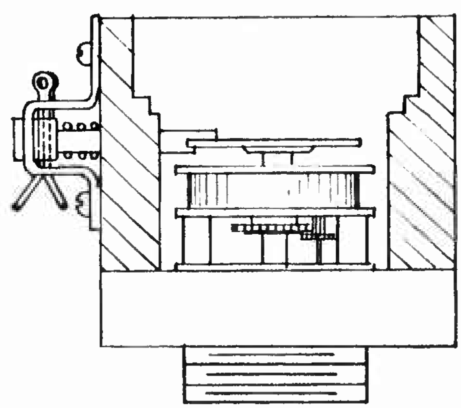
STARTING & OPERATING TORQUE - Para 4.4.3



GEAR TRAIN PROOF LOAD - Para 4.4.4



TRANSPORTATION VIBRATION - Para 4.4.5



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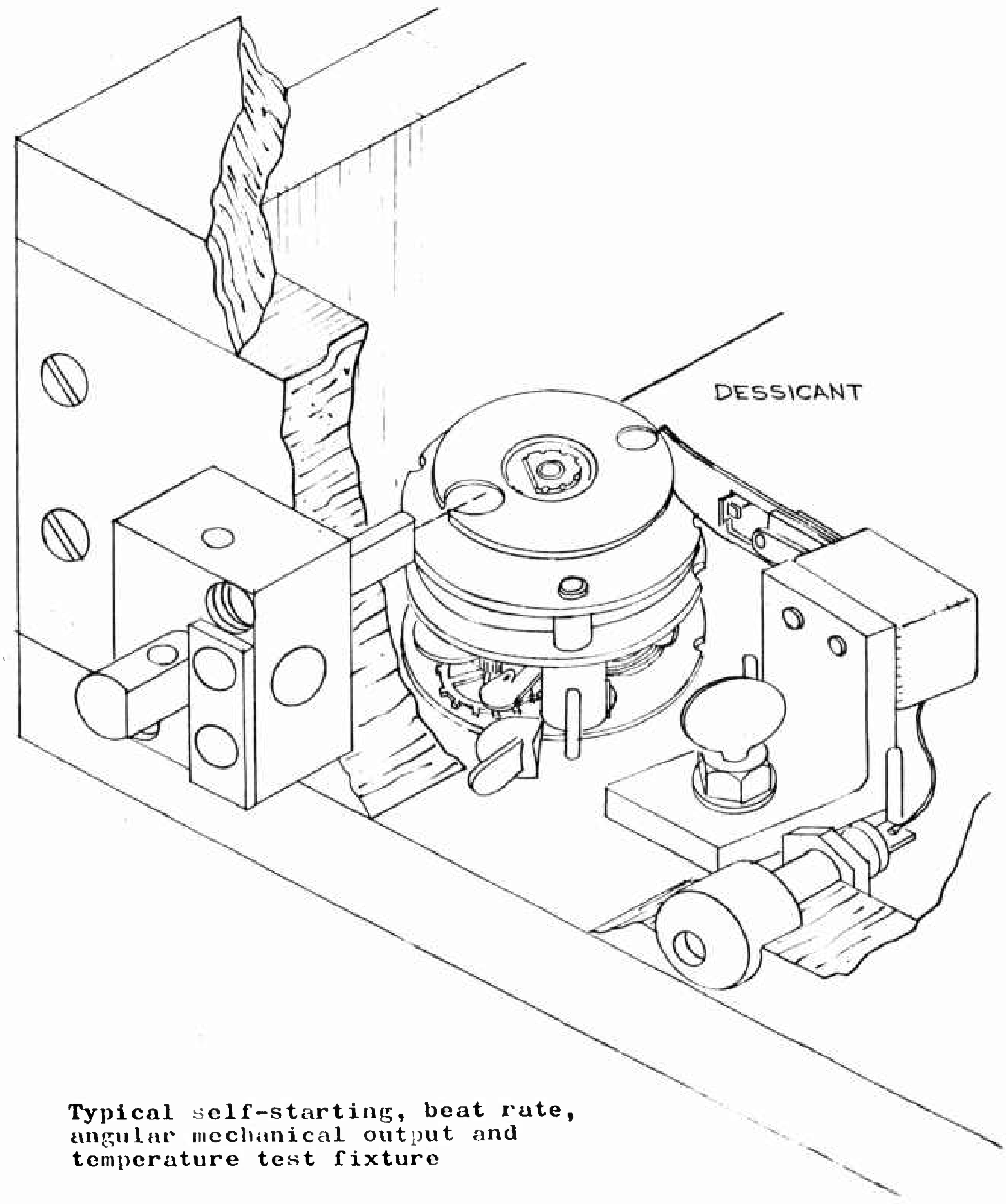
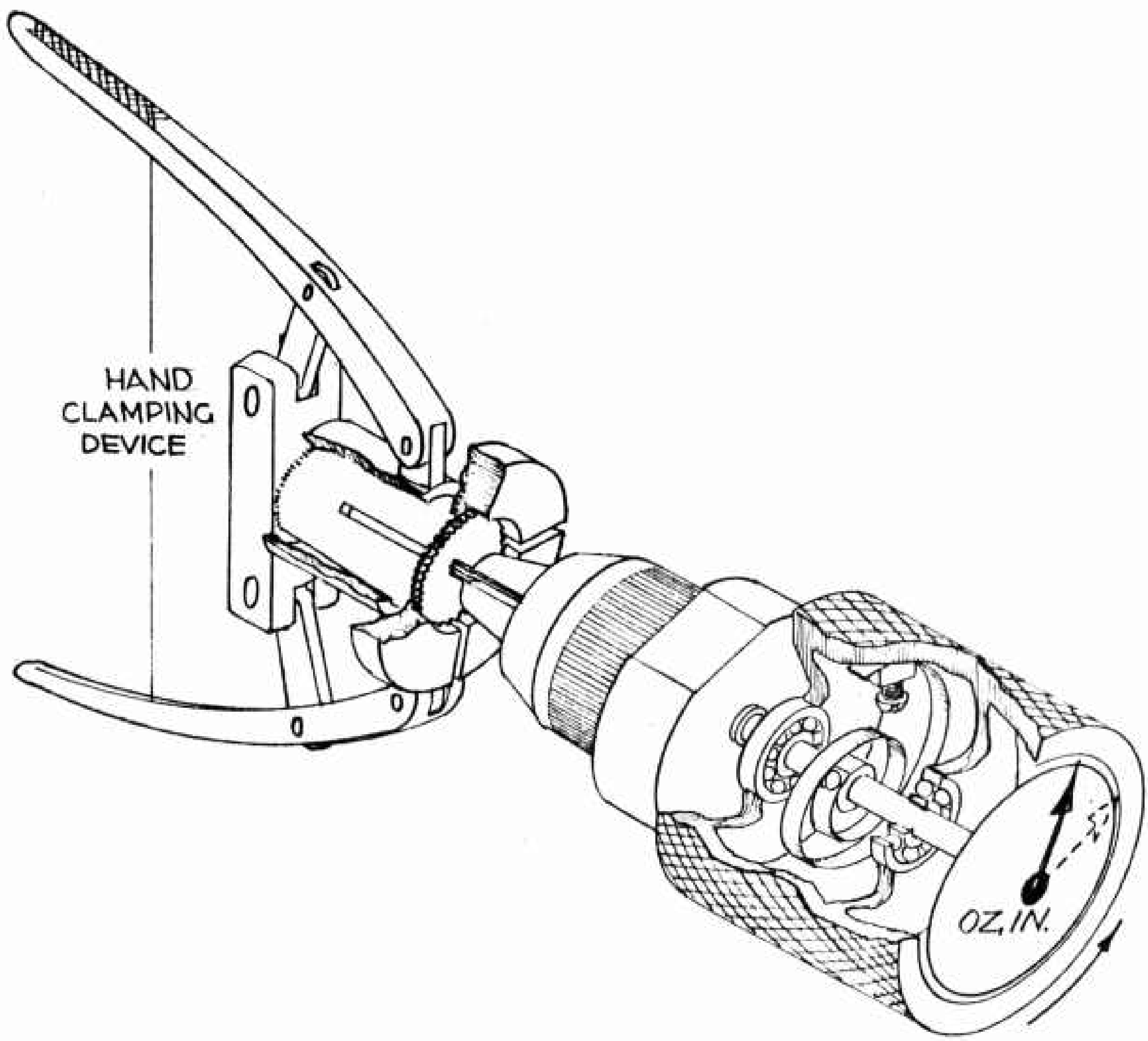
FUNCTIONING - Para 4.4.6



Typical self-starting, beat rate, angular mechanical output and temperature test fixture

TORQUE TEST - Para 4.4.7



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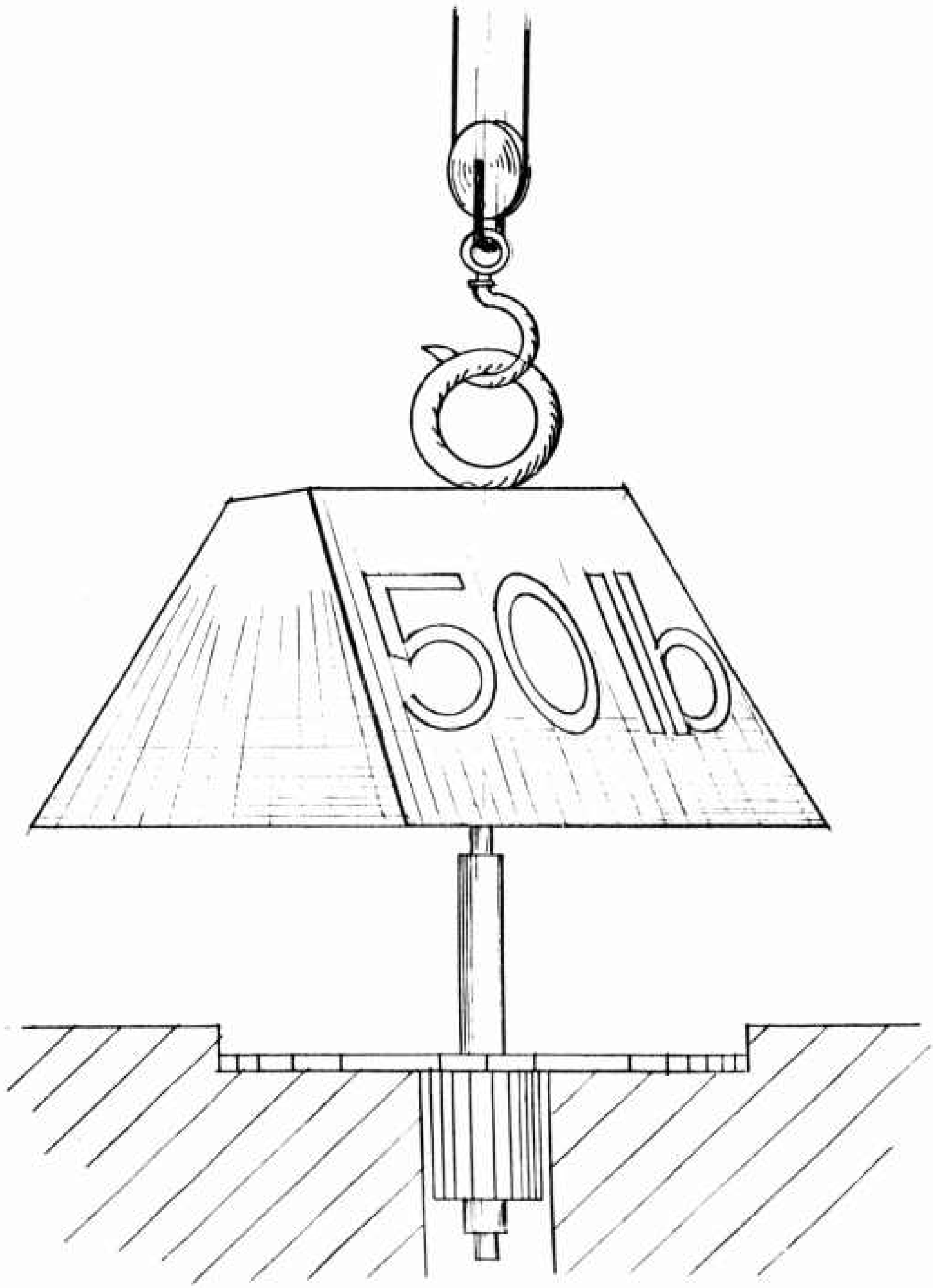
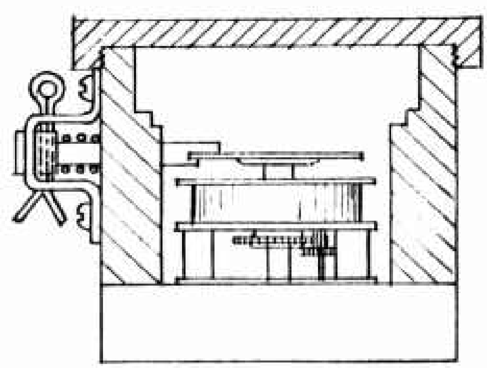
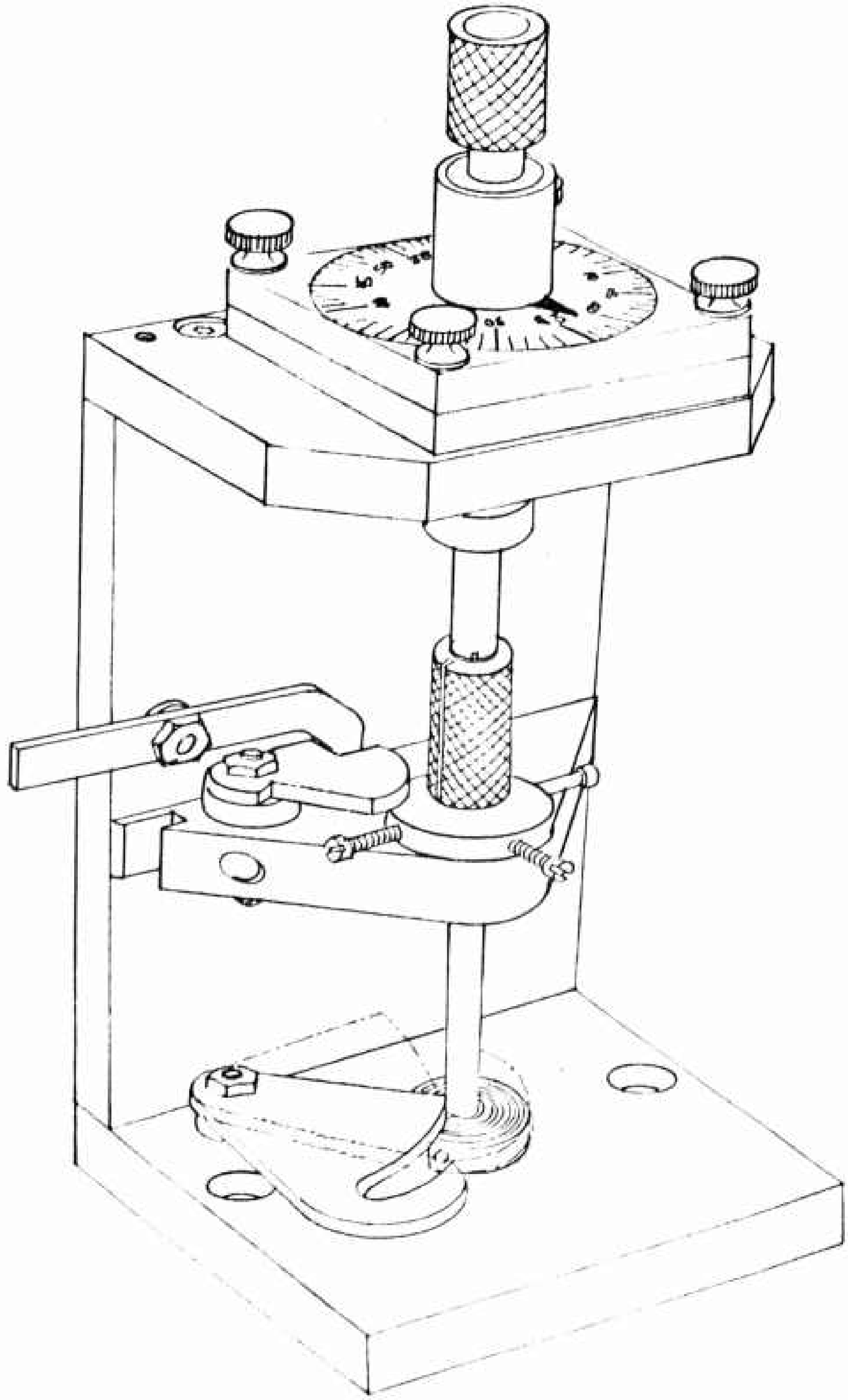
LOAD & PULL TESTS - Para 4.4.8



JOLT & JUMBLE - Para 4.4.9



MAINSPRING TORQUE - Para 4.4.10



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Standard Equipment For Load, Pull & Torque Tests

Description	Model	Specification Test Para No.	Range
Hunter Mechanical Force Gage	L-20M	4.4.8	0 - 20 lbs.
	L-30M	4.4.8	0 - 30 "
	L-50M	4.4.8	0 - 50 "
Waters Torque Watch	651C2	4.4.7	0 - 20 oz. in.
	651C3	4.4.7	2 - 40 " "
Power Instrument Torque Meter	783C25	4.4.2	0 - 25 oz. in.
	783C40	4.4.4	2 - 40 " "

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SECTION XI

COST COMPARISON OF R & D AND P. E. MODELS

COSTS		DESCRIPTION		COSTS	
PART	ASSY	R & D	P.E.	PART	ASSY
.15		Plate No. 1	Plate No. 1	.03	
.025		Pillar No. 1	Pillar No. 1	.025	
.025		Pillar No. 2	Pillar No. 2	.025	
.025		Pillar No. 3	Pillar Hrsp.	.045	
.015		Rivet regulator			
.025		Regulator			
.015		Support Regulator			
.015		Screw Regulator			
.02		Nut, Regulator			
	.09				.052
			Click	.015	
.015		Gear, Center	Gear, Center	.03	
.12		Arbor, Center	Arbor, Center	.12	
	.033				.054
.035		Pinion No. 1	Pinion No. 1	.035	
.005		Gear	Gear	.005	
	.02				.02
.035		Pinion No. 2	Pinion No. 2	.035	
.005		Gear	Gear	.005	
	.02				.02
.035		Pinion, Escape	Pinion, Escape	.035	
.05		Wheel, Escape	Wheel, Escape	.05	
	.02				.02
.04		Pallet	Lever, Pallet	.01	
.05		Staff	Pin, Pallet	.02	
.005		Collet, center	Pin, Pallet	.02	
.005		Collet, outer	Shaft, Pallet	.025	
.02		Hairspring	Pin, Impulse	.02	
.005		Weight, Pallet	Mass, Balance	.005	
.005		Weight, Pallet	Shaft, Balance	.05	
			Hairspring Hub	.005	
			Hairspring	.03	
	.12				.203

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COSTS PART	COSTS ASSY	DESCRIPTION R & D	DESCRIPTION P.E.	COSTS PART	COSTS ASSY
.03		Plate No. 2	Plate No. 2	.03	
.015		Bushing, Wind Pinion	Hairspring Lock	.01	
.06		Barrel	Screw	.03	
.07		Spring, Main	Mainspring	.08	
.015		Hook, Mainspring	Plate No. 3	.03	
.005		Screw Pillar			
.005		Screw Pillar			
.005		Screw Pillar			
.015		Click			
.015		Shaft, Click			
.005		Spring, Click			
.005		Spacer			
.005		Spacer			
.005		Spacer			
.005		Washer Barrel			
.03		Plate No. 3			
.01		Bushing starter			
.005		Spring starter			
.01		Starter No. 1			
.005		Washer arbor			
	.65	(Assembly & Final Inspection)			.491
.015		Nut, Movement		.015	
.015		Disc		.015	
	.025				.025
1.095	.978	Parts & Assembly Costs		.850	.885
	.219	Tumbling, Incoming Insp., Qualification Tests and Certifications + 20% of Parts Cost			.17
	1.197	Total Direct Labor			1.055
	1.197	100% Burden on direct labor			1.055
	2.394	Direct Labor and Burden			2.11
	1.095	Cost of Parts			.85
	3.489	Total Cost Including Tooling			2.96

The above costs are based on a production rate of 5,000 movement assemblies per day, single shift.

SECTION XII

DOCUMENTARY WORK PERFORMED

The following documents were prepared and forwarded to Picatinny during the course of this contract.

I FINAL DRAWINGS

The first set of manufacturing drawings were revised to reflect the government inspector's viewpoint. The manner in which this should be done was explained by P. A. Gage Design. We prepared a set of concept drawings depicting how to best accomplish this end. After concurrence by the Picatinny Arsenal Project Engineer, we changed all drawings to basic dimensions and tolerance zone diameters. Although this system could be used for manufacturing purposes, it is primarily designed for the inspector. Functional go, no-go gages can be utilized, saving considerable inspection time.

II SPECIFICATION DRAFT

Such a Specification Draft, being without precedent for such a high beat, detached pin lever escapement, required considerable effort in its preparation. Repeated revisions were made to reflect developments as they occurred during the four fabrication stages of: testing, 50 test samples, 25 pilot lot and the 250 production quantity. The final draft provides adequate quality assurance to the procuring agency consistent with reasonable inspection costs and delays.

III NOTES ON DEVELOPMENT TYPE MATERIEL

These notes are brief yet familiarize the reader with potential applications by outlining the main areas in which the R&D and this final production engineered version differ. Characteristics of performance and capabilities were briefly outlined and a typical method of operation is pictured.

IV INSPECTION EQUIPMENT CONCEPT SKETCHES

Due to the small quantity produced under this contract, test fixtures were illustrated in concept form rather than as detailed, dimensioned, manufacturing drawings. Fixtures with special loading means are needed to efficiently process regular production quantities.

V SEQUENCE OF OPERATIONS

The Sequence of Operations contains an isometric with numbered areas briefly described, a narrative of production difficulties encountered and how resolved. A bill of materials precedes a process flow chart covering related drawings. Listings of sequence of operations performed on component parts and assemblies completes this document.

VI FINAL SUMMARY REPORT

This report was prepared with the intent of imparting a general understanding of the reasons for this development, why and how specific areas were modified, resulting drawings, specifications and capabilities.

VII LUBRICATION STUDY

Due to industry-wide confusion relating to lubricants as well as the loss of accuracy encountered in this redesigned timer at -65°F, we conducted an intensive lubrication study. A most satisfactory dry lubricant was found and is specified on related drawings. This study is included in the Final Summary Report.

SECTION XIII

SUMMARY CONTRACT FINANCIAL STATUS REPORT

		Total Authorized
Original Contract, 8 Aug 1960 Est. Cost \$44,732.00 Fixed Fee \$2,055.00	\$	46,787.00
Modification No. 1, 15 Nov 1960 Administrative change for submission of Financisl Management Reports (no change in est. cost)		
Modification No. 2, 6 Feb 1961 Authorization for purchase of equipment (no change in est. cost)		
Modification No. 3, 4 Apr 1961 Time extended to 10 May 1961 (no change in est. cost)		
Modification No. 4, 21 June 1961 Time extended to 30 June 1961 (no change in est. cost) Contract Number Amended to read "DA-28-017-ORD-4029"		
Modification No. 5, 27 June 1961 Time extended to 15 Dec 1961 Estimated Cost increased \$17,694.29 to (no change in Fixed Fee)		64,481.29
Modification No. 6, 24 Aug 1961 Administrative change deleting the requirement of sending monthly reports to the New York Procurement District (no change in est. cost)		

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	Total Authorized
Modification No. 7, 1 Dec 1961 Format for Progress and/or Summary Report (no change in est. cost)	
Modification No. 8, 9 Feb 1962 Administrative change in accounting classification (no change in est. cost)	
Modification No. 9, 24 May 1962 Supplemental Agreement increasing estimated cost by $26,289.86 to (no change in Fixed Fee)	90,771.15
Modification No. 10, 20 June 1962 Final settlement of actual overhead rate to completion of this contract (no change in est. cost)	
Modification No. 11, 5 Feb 1963 Supplemental agreement increasing the estimated cost by $14,655.23 to (no change in Fixed Fee)	105,426.38
Modification No. 12, 31 May 1963 Due to underestimate of costs this supplemental agreement increased estimated costs by $7,112.40 to (no change in Fixed Fee)	112,538.78

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